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Meaningful Independent Practice in Mathematics

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Abstract

In this action research of my seventh grade mathematics classroom, I investigated how students' explanations of math homework would improve their learning in math. I discovered these explanations can be very beneficial in helping students to improve their understanding of current skills although it did not affect all students. As a result of this study, I plan to incorporate these student explanations in my instruction next year but not as a daily expectation.

My goal was to address meaningful independent practice for my students rather than focusing on daily homework assignments. I believed there were many reasons daily practice was important for my students' skills and understanding. My goal was to address these needs for practice in the most effective means possible. I had done a great deal of practice using homework, as well as observed the practice of other teachers. I had come to find it was not necessarily what I assigned but how I used it.

Previously I assigned homework as individualized practice at the end of class, but the next day there was a new objective and not enough time to go over every homework problem. If I did not have the time to go through every problem, then I wondered if there were more I should be doing with independent practice to make it a more valuable learning experience for the students. Students were using their given class time to start their work, but the drive to accomplish the work on their own was not there. This had me questioning what I could do differently to develop an internal drive in students to complete their math practice outside of the class. I wanted to find a way to move from either having the students doing their independent practice to turn in with no time for reflection, or spending half our period reviewing what we had learned the day before while going over the practice. My thought was when the students are able to explain how they found a solution I then have a better understanding of what they know than if they were to successfully practice 20 examples.

After all my thoughts, observations, and discussions, I decided to adjust what I assigned for homework and how I used it in my classroom. I wanted to take examples from the homework, especially problem-solving examples, and have the students work through the problems and then explain their answers in complete sentences. My goal was to turn the learning into teaching for each student to increase the validity of the learning. For the students to teach,

they were required to explain to me how they arrived at their answer, rather than just completing practice together. I believed it is a better example of learning when a student is able to tell me how they solved a problem rather than completing problems on which they may have received help. This then allowed the students to have control of the review by explaining to their classmates how they solved their homework and where we needed to have further discussions.

There were also additional benefits to having homework structured in this manner, including the school improvement goals. With math and writing scores at the forefront of the minds of many administrators, an opportunity to bring the two together was ideal. In my building our goal was to include writing across all curriculum areas. The idea at our school was if students saw these goals were important to everyone, especially those outside the English department, they would become more involved. I wanted students to see the benefit to practice and to contribute to their success. I noticed many connections in my research to the National Council of Teachers of Mathematics (NCTM)'s Principles, Process Standards and Content Standards, especially in the areas of the number and operations standard and problem solving. In the NCTM's numbers and operations section the word "understand" appears frequently; the word sums up my goal for the students not to remember but to understand. I could have a student engage in a lesson, practice with a partner or the class, and then work on their own successfully without fully understanding the concept. The overall goal of my research was to have the students to take a moment in their learning process to make sure they understood the material and not just memorize what they needed for their next assessment.

The second part of the NCTM standards that I focused my research on was solving story problems, or problem solving. There were numerous steps in solving a story problem beyond the solution of the actual problem. In real life for most students, math was story problems, or

problem solving. When they were faced with math, it would not tell them what formula or operation to use; this was what we, as educators, needed to do to ensure they truly understood. My goal was by having students write out their thoughts, it may help them think through the problem and discover what path to take in solving.

This brought me to an additional part of my research, the idea of multiple methods in solving a problem. In real life one is not told how to use the information they are given, students may discover different manners in which to find the correct solution. This was also an important element to demonstrate to students, that there was not one specific way one must use to solve all problems in math. These two pieces of my research were based on helping students and ensuring they understand.

In this action research to develop student understanding, I had students write their homework solutions in complete sentences. Students were given either regular math computation or practice problems to solve and then were asked to explain how they discovered the answers. Students also were given story problems and were expected to communicate what thoughts went through their mind and how they found their solutions. The discussion of the write-ups in the presentations also showed the students how many different, but correct, ways one can solve a problem.

The NCTM standard of communication was most closely tied to my action research project. Communication is the students' ability to take their mathematical knowledge and share it with teachers, peers, and others. Such communication involves students using mathematical terminology and understanding to clearly and correctly explain their thought processes related to math. In this action research project, students had to use the current and previous math terminology and concepts to explain how they solved their problem and why this was a correct

means of finding their solution. Through classroom presentations, students then needed to transfer their understanding to an explanation in front of the class.

The change in the way I assigned homework or independent practice allowed the student to find a mathematical voice: a way to explain their thoughts with their peers, parents, and instructor. In representation, an additional NCTM standard, students drew what they were trying to find and visually explained their thoughts. By using representations, some students then could be more successful in turning these thoughts and ideas into complete sentences. Overall, explaining required a higher level of thinking for the students. When children took what they understood and put it in their own words, they were not only checking their own thoughts for understanding, but also were creating a deeper knowledge. Writing their homework in complete sentences and presenting it to the class gave the students the chance to create that deeper knowledge as well as allowed time to give the assignment the focus the students deserved.

Problem Statement

In education the overall goal was for learning, and in this research my focus was on how I could make learning better. The most widely used way to determine if an individual understood a concept was through an assessment. In reality, assessments do not show that a concept is necessarily understood, they are rather a result of students simply reciting what they recently learned. In my research I hoped to create a deeper understanding of math concepts in students and to improve their ability to explain their mathematical thinking. My goal was to have students understand the material, write and talk about the concepts, and question their understanding, so they had the tools to use what they have learned later in life, and not just for the assessment at the end of the section.

Literature Review

The issue of homework is a continuous discussion in the world and study of education and best educational practices. The problem I encountered in my classroom was a lack of homework completion. The emphasis of my research was on homework, focused on finding a new approach.

With this in mind I found many other educators and researchers who studied how students' written or oral explanations could improve learning, as well as finding multiple methods of solving problems, especially in problem solving or story problems. However, I did not find another study combining the three. I found three themes in these studies; the first was written explanations. This was when students were asked to write about math, although different researchers chose to do this in a variety of ways. I explored the students' reasons for writing, methods and findings to help develop my research. I also found many researchers who talked about students presenting their math to their peers; this also could be handled in many forms. The final theme I found in the related literature was problem solving. I was looking for finding multiple solutions but most researchers discussing multiple solutions in math were discussing problem solving.

Written Explanations of Mathematics

In the age of assessments, as an educator I sometimes feel stressed to teach the objective at hand rather than the subject as a whole. In my action research, I gave my students a problem and asked them to give me a written explanation of how and why they came to their solution. I hoped by doing this I would be seeing less reciting what the students were just taught, but rather more of what connections they have made and what concepts they understand. Pugalee called this writing thinking aloud on paper (2004).

In Pugalee's (2004) study, students were practicing problem-solving examples. To prepare students to complete written math explanations, the students were involved in a two-week period focused on problem solving and writing each and every thought down on paper. Each day the papers would be returned to the teacher; the teacher would read, comment, and question the student, then return the work the following day. This period was to help the students think about how to explain the process of solving a problem; the teacher responses were to help them see how to make their writing more pointed. After this period the students were given the option of writing or orally explaining their solutions. This study of a ninth grade algebra class was meant to determine if either written or oral explanations are more reflective of student understanding than the other. According to Pugalee "students who wrote about their problem solving processes produced correct solutions at a statistically higher rate than when using think-aloud processes" (p. 43). Pugalee was an associate professor in education at the University of North Carolina in Charlotte. It was in Charlotte where he coordinated the doctoral program in instruction and curriculum. His focus was on math, particularly on the relationships between mathematical learning and communication.

The writing the students completed for homework was intended to be the discovery of their personal meanings of the objective. Mosenthal (1995) discussed a "constructivist" way of learning saying that "individuals must construct their own understandings of mathematical principles and concepts" (p. 266). Mosenthal studied the change in teachers' instruction after a year and a half of summer in-service in Summermath. The focus of this in-service was to instruct teachers how to help the students take a more hands-on approach to their own learning. The training included the teachers having their students construct their learning, from what they know and the problems they are presented with. In Mosenthal's study, there was an in-depth look into

two teacher in-service trainings, not only Summermath for Teachers, but also Teachers College Writing Project. These in-services where studied through the Teacher Education and Learning to Teach Study program through Michigan State University's National Center for Research on Teacher Education. At the conclusion of the study, post-training teaching was compared to included teachers' pre-training teaching. Judith, a teacher trained in Summermath for Teachers, adjusted her class to constructivist mode post-training. She now focused more on the learner than the end result. The author, Mosenthal, was an associate professor in education at the University of Vermont. At Vermont, Mosenthal specialized in literacy and reading, assessments, and teacher preparation programs.

Similarly, Shield and Galbraith (1998) stated "writing is thought to promote a personalized and constructive approach to learning" (p. 30). This research reiterated the benefits to writing in mathematics, but also focused on instructing how to write in mathematics and writing found in math textbooks. The results were taken from observations of three eighth grade classes, one class from an inter-city all-girls school, and two classes from outer-city and co-educational schools, with each class including about 25 students. For the research, the students were asked to write a "how to" letter of what was learned that day to a classmate who was absent. They were to explain everything the student had missed in the letter. Two writings like this and various other expository writings were gathered, from researchers visiting the classroom to conduct writing activities. In the end the study had gathered a total of 290 expository writing samples on which to base the data. With a great deal of research focused on the benefits to writing in math, Shield and Galbraith (1998) did not find a correlation between students' knowledge and writing. However, Shield and Galbraith did believe there was evidence throughout the course of their research that understanding had improved. Shield and Galbraith

were both math educational researchers out of Australia. Shield is currently at Greenland University of Technology, and his focus was on secondary math, as he is a former secondary math teacher himself. Galbraith was an adjunct professor at The University of Greenland.

Clarke, Waywood, and Stephens (1993) discussed NCTM's views stating "the NCTM document *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) lists "Mathematics as Communication" as its second standard, preceded only by "Mathematics Problem Solving" (p. 235). Their research is focused on one form of mathematical communication, student journaling. In this research, that took place in an all-girls' Catholic school in Melbourne, Clarke, Waywood, and Stephens studied the use of journaling in math and its effects in the classroom for grades 7-12. To determine the results of journaling mathematics, teachers along with the students completed questionnaires about the effects of journaling to learning, for either themselves or their students. Clarke was the director of the International Centre for Classroom Research at the Melbourne Graduate School of Education in Victoria, Australia. The focus of Clarke's research was centered on classroom practice. Waywood worked with Clarke in the Mathematics Teaching and Learning Centre at the Australian Catholic University. Stephens worked with Clarke at the Melbourne Graduate School of Education.

The concept of journaling may not be as easy for all students. Burton and Morgan (2000) stated "in the educational context, students at many levels find writing difficult and may not communicate their mathematical thinking effectively" (p. 430). Burton and Morgan looked at how language was used in math classrooms, whether by teachers or students. The research was done by having the participants analyze 53 other studies. The research consisted of 35 men and 35 women analyzing the 53 articles about communication in the math classroom and then being interviewed about their thoughts on the reading. Their research was focused on writing about and

discussing mathematics. In studying previously published math research papers, Burton and Morgan were able to analyze mathematical writing. In the end the research that was being studied was to have students write about the math concepts they are learning. Burton and Morgan were both educated in the field of math and education. Burton was a professor of education at the University of Birmingham, England, and an advocate of women in mathematics. Morgan was faculty of the Department of Geography, Enterprise, Mathematics and Science from the Institute of Education out of the University of London, and previously a secondary math teacher.

While each of the five studies discussed all addressed writing about math in some way, they were all very different in nature, and none of them were a combination like my research. The closest research to my own was Pugalee (2004). This was the study where students chose to either give their explanation in either written or oral form, unlike mine where they had to do both. All students in my research had to submit a written explanation but then during class selected students would share an oral presentation. Mosenthal (1995) was focused more on problem solving, which was an underlying topic I addressed, but for this research they investigated how a teacher training would change student learning. I did not change my instruction, or seek any specific training but rather changed the focus of the students' independent practice. Knowing a great deal of independent practice was taken from the text, Shield and Galbraith's (1998) research of how math was written had another view on writing in math. They also had students write, but with a very specific focus, of explaining to an absent classmate. These were similar to the write-ups I was seeking from my students: a conversation on paper. Another form of discussing math in writing was the option of journaling. Clarke, Waywood, and Stephens (1993) included this in their research. The route Burton and Morgan (2000) took was to look through existing research and gathered data from what teachers gained

from those. This was done through the use of interviewing, a common piece to many of the studies. In the end though, everyone fit their study to the information they were seeking, and there was not a study I found wanting to put these pieces together to make the same connections.

Verbal Explanations of Mathematics

In my research, after writing their homework in complete sentences, some students were selected to share the methods they had used to solve the problem. I called these homework presentations. This required oral explanations, when students explained how they solved a problem orally rather than writing out the response. This was just one part of what I asked the students in my study to do every day. The possibility for students to go in front of their classmates and make a mistake was always there, but the task of talking about math was still important. Burton and Morgan's (2000) research talked about the importance of talking about math but also teaching students how to do so.

Pugalee's (2004) research of whether written or oral explanations yielded more success resulted in no statistical data that written or oral did better than the other. Pugalee did find the majority of the time on any given problem, that the majority of the students chose the same way to present the problem, whether written or oral. Pugalee found when most student strategies were the same there was a higher probability of student success, but when there were a variety of strategies there was a higher probability of student mistakes.

The studies having students give oral explanations were not as common as the written responses. Pugalee (2004) allowed the students to choose between written and oral explanations. In Pugalee's approach, there was no instruction on how to communicate math concepts. Much like in my class, the students did not need the guidance as much on how to verbalize a problem's

solution as they did to write up a problem's solution. Burton and Morgan (2000), however, discussed how important it was to talk about math, and to teach students how to talk about math.

Multiple Solutions in Mathematics "Story Problems"

NCTM discussed the fact that basics were important but not by just memorizing facts. NCTM discussed the need to know how or why, so students could solve problems they had not encountered before. The idea of understanding the concepts rather than just memorizing procedures was why I chose to include story problems as a part of my research.

Lubienski (2000) discussed NCTM's belief that math education should be centered on problem solving. Her research, where she served a dual role of researcher and program piloter, looked at how students in her classroom learned using the Connected Mathematics Project (CMP) method of teaching. Lubienski discussed the benefits to focusing learning on problem solving rather than have "students complete meaningless exercises and memorize what the teacher tells them" (p. 456). She saw more importance in practicing the mathematical ideas using problem-solving examples. To track the progress of the research she used interviews, teacher journals, student work, and surveys. Lubienski found the results were a reflection on the student's ability or willingness to accept the change. Learning through problem solving did not only require a different way of thinking but was also a harder way of thinking. There were students who did not want to change from the traditional way of learning and were not willing to break the mold of how math should be or had been taught. But overall in the end many students felt the CMP program required them to think more and helped them see how math related to real life. Lubienski was an associate professor of curriculum and instruction at the University of Illinois at Urbana-Champaign. She had been the principal and co-principal investigator of two grants through local colleges, as well as the principal and co-principal investigator of two grants from the U.S. Department of Education.

Lubienski (2000) and the NCTM's learning principle are similar to that of Mosenthal (1995). In his research, Mosenthal stated the student's need to "'understand' content and not simply cover" (p. 272). This was a theme I found in Mosenthal's research, seeking a better way to learn math using problem solving and student discovery.

Bryan and Sullivan-Burstein (1998) found a correlation between homework completion and performance scores in real-life problems. In their research they observed changes in homework completion and performance scores for math and spelling. The researchers split the students into four categories: students with homework and learning disabilities, average students with homework, students without homework and learning disabilities, and average students without homework. Assigning real-life homework was one of three strategies that caused a statistical increase in homework completion of the students. The study included 11 teachers in a K-6 elementary of 700 students over a two-year period. Bryan and Sullivan-Burstein, both principal investigators of the Southwest Institute for Families and Children with Special Needs, an organization in Scottsdale, Arizona, which researches, demonstrates, implements, and evaluates educational ways of assisting students with special needs, met with the teachers on a weekly basis to gather data and share ideas.

Finding more than one way to solve a problem was not as readily available in research as just the inclusion of problem solving in general. Across the board these studies thought learning through problem solving enhanced the learning of math. Lubrenski (2000), Mosenthal (1995), and Charles and Lester (1984) all had training implementation they were observing for the research. The training was either solely or at least partially about using problem solving to teach mathematics. In Lubrenski and Mosenthal, the attention was on how the teaching changed for the

teacher. While Charles and Lester, along with Bryan and Sullivan-Burstein (1998) were focused on watching and observing how the students changed.

Conclusions

There are many underlying issues for the lack of homework participation, and no one solution will fix everything. It is still important to always seek a better way of teaching and learning. Many of the underlying ideas of my action research and the research that I read followed very closely to the thoughts of the NCTM. The goal is to improve student learning, and success found in trying is worth the effort.

In my own research, I incorporated problem-solving practice to improve my students' understanding, but I also chose to do this using writing and orally communicating their thoughts. The articles I read addressed the same issues of why they wanted students to write to have a more authentic learning, and in speaking. The purpose of both of these was to have the student take their understanding of the concepts and explain problems in their own words. I chose to have students do a combination of both, which is different from any of the research I was able to find. I wanted the written work as their independent practice to express their understanding, then the oration as the class discussion. These class discussions allowed students to share their thoughts on the given problem, enabling students to see how they may have done a problem differently. For many of the same reasons, I wanted students to create a deeper understanding of math, to make connections, and to be able to relate what they learned to real life. I hoped by explaining their understanding it would help students learn; I also wanted to have student-focused reviews. By doing the homework presentations I, as well as the students themselves, would be able to see if there were students who may have solved a problem differently from students, or, most importantly, if there is a concept we need to revisit before going on. This

allowed for a quick, student-based review, but still was a valid use of class instruction time. Overall, the goal was to create a deeper understanding of the material.

Purpose Statement

The purpose of this study was to create a deeper understanding of math concepts through student writing and personal explanation of their understanding. For this research I started by changing homework from repetitive practice to having students complete fewer problems but explain their solutions in complete sentences. The following day when turning in their work, students then would present their work to the class. This allowed for not only incorporating written explanations but oral explanations as well. For some students, writing out an explanation may be more or less difficult than an oral explanation. In student explanations I looked for instances where there was more than one way to find the solution. The purpose was to find out if explaining their work through writing, especially the practice of complete proper sentences, would have an impact on the students' achievement in assessing those concepts of the mathematics. In addition I was seeking to find if the verbal presentations of how a student solved a problem would improve the individual student's or surrounding students' achievement of the current mathematics material. Finally, the overall purpose was to investigate if the change affected student learning. In studying the change of learning I was looking for three main questions to be answered: 1. What happens to student achievement in mathematics when students are asked to explain their learning in writing? 2. What happens to student achievement in mathematics when students are asked to explain their learning orally? 3. What happens to my teaching when I ask students to explain their thinking orally and in writing?

Method

To find the answer to these questions I used various research strategies. I collected data from February 14, 2009, to March 17, 2009, in my seventh grade math class. The data included recording classroom data, including formative and summative assessments, formative assignments, and grading practices. I also gathered input from the students; this was done through student surveys and student interviews. Finally, I recorded my thoughts in a journal so that I would be able to track the progress in my mind throughout the project.

Data gathered in the classroom consisted mainly of the students' independent practice, or formative assignments. During this research the majority of the assignments required at least a portion to be completed in complete sentences. Each written portion of an assignment was graded using a rubric (Appendix A), and then presentations given were graded using a separate rubric (Appendix B). At the beginning of the semester the presentations were graded using a three-category, three-point rubric. The rubric included the students sharing what they are thinking, their correct use of concepts and vocabulary, and finally their connection to current lessons. But soon I realized there was not enough time to complete everything I had hoped for in the blocked amount of time. At that point I decided to have the students present and rather than grading them with the rubric I questioned them for more information when they were not meeting one or more of the three categories on the presentation rubric. I found a need for more instruction time, just to assist students in the adjustment in the method of homework and presentations. At the end of the day, I wanted more focus to be on their writing, and to allow for the presentations to be a student-lead class discussion rather than grading the one individual student presenting.

I found the homework completion rate for the seven assignments, during the second semester, before the research started (Appendix C). Homework before the research usually consisted of 12-20 problems out of the book. There were usually three examples of each topic we had covered that day, meaning there was a lot of repetitive practice in the previous homework. In addition, I found the homework completion rate for the 22 assignments during the research (Appendix D.) Homework during the research consisted of 3-10 problems depending what was being taught. In some assignments, all the problems had to be explained in complete sentences and in some there were no problems to be completed in sentences, but the majority had about one-third to one-half of the problems that needed to be written in complete sentences.

Along with independent practice, I compiled the scores of the formative assessments before the research (Appendix E). A formative assessment was usually a Friday quiz; otherwise, it was a warm-up from the previous day's lesson. Summative assessments also were tracked before the research (Appendix F). Summative assessments were the district-created assessments over the material to prepare students for the end-of-the-semester test. Data also was compiled for the formative assessments during the research (Appendix G) and the summative assessments during the research (Appendix H). To track how any particular student did, or see how his or her explanations changed over the course of the research, I also kept copies of the students' formative and summative assessments (Appendix I).

I also gathered data through student interviews in late March and early April, with a variety of pre-determined questions to discuss (Appendix J). The questions included the discussion of homework, presentations, the changes and their suggestions for the future. There were a total of three interviews completed during the research, with detailed notes of the students' thoughts on the research topic (Appendix K). Each interview had two to three students

present out of a group of five who were interviewed at one point in the research, so some students were interviewed more than once. Along with interviews, an additional way for students' opinions to be voiced was through the survey (Appendix L) they each completed at the end of the semester. I have compiled the results (Appendix P) to see how the class as a whole felt about change in homework and class instruction.

The last piece of data was my weekly journals, where I answered the same questions (Appendix P) each month. The journals were to find where I was at in the research, what changes I have noticed, and what my next step will be. I stopped every Friday, if not more than that one time a week, to reflect on what I saw, how things changed, and what I wanted to do from there. I also kept copies of student quizzes and teacher's grade book to measure students' mathematics achievement throughout the research (Appendix A).

I also collected data to investigate if shortening the homework assignments and stressing on the students' explanations would improve learning of the objectives and completion of homework. This was done by eliminating extra practice, and focusing on the goal of seeing what happens to homework completion when there is less quantity and the stress is on the students explaining what they know and understand. To investigate this, data was kept on homework completion and class presentations (Appendix A). Interviewing five students about their feelings on this was done in the three interviews during late April to early May (questions found in Appendix C).

When analyzing and using the data I first looked at how homework completion changed from before the research to after (Appendix A).This would help me determine if the focus on explanations rather than quantity would increase homework completion. Because the class struggled with homework completion so much throughout the entire year, a change would not

necessarily mean very much since they so much room for improvement. The data would only make a large impact on the findings if there was a considerable increase in completion.

I also could look at how the overall grades changed over this time. However, to look at individual student work was much more difficult since very few students returned their permission form to be a part of the actual research data conclusion. This would mean I was only able to compare the class average changes and how students who returned their forms performed. I do, however, need to take the change in homework into account in viewing the homework completion rate. The time span of the data may not have allowed for a true picture of the benefit of this task. The students seemed to need a great deal more instruction on how to complete math homework and write up their solutions in complete sentences than first expected. Student absences were also a factor in the homework completion and assessment results during the research.

Students also received three formative assessments and 19 summative assessments during this time. The original plan was to have a quiz each week but with explaining the new homework format, practicing as a class, presenting in class, and allowing more time in class to ask homework questions during the transition period, the formative assessments just did not seem to be feasible each week. Also, the objectives during this research period were some of the most difficult objectives of the year. This would mean the data would not be a true picture of the changes' effects on their assessments. So while there was data on the students' homework, formative, and summative assessments the true picture of this research would come from their opinions.

Findings

My intention was to find what happens to student achievement when students are able to explain their learning in writing or orally, how these explanations change their learning, and how the changes affect my teaching. The data was gathered in a seventh grade, on-grade-level, math class. The class consisted of students either working successfully at grade-level material or needing extra assistance; high-ability learners were in a differentiated class. The class occurred in the middle of the day right before lunch for the students and was their last academic class before they finished their day with academic connections classes such as PE, Music, or Art. In the 52-minute period, 13 to 16 students were instructed by a math teacher and a special education co-teacher. The co-teacher was available due to having over 50% of the class identified as special education (SPED) or as English Language Learners (ELL).

A typical day in this class would first start with the students entering the room to a warm-up question on the board. The warm-up was either a review from the day earlier, a preview for what would be taught that day, or a review of any previous concepts. The warm-up was not a new concept for these students since this was a building policy that all classes started with the same structure. The students knew the expectation of them was to walk in, prepare their materials and begin their warm-up problem. After attempting the warm-up problem on their own, the class discussed the warm-up together. The warm-up also was sometimes collected as a formative assessment as a review of the previous day's material. This typically was the students' opportunity to see if they had questions on the previous day's homework or class work, and have those questions answered.

The students were then asked to find their homework from the previous day, and volunteers or selected students were asked to present their prepared homework to the class. The

prepared homework was the problems students were asked to write in complete sentences. The presentations were typically one to two minutes in length and were just the students explaining orally what they were to explain on paper for the homework. However, there were some students who had completed the homework problems, but did not write their responses in complete sentences and were still chosen to present with the explanations expected in the sentences. When presentations were complete I discussed any other questions students had on the homework. However, the students' presentations would typically answer any questions, or the students would question their classmates during their presentations with any questions they did have.

After the questions were complete we would have our lesson for the day. The lesson may include notes, practice, pairing, or an activity; any lesson for the day focused on the concepts, definitions, and procedures for the current lesson. By focusing on these, the students knew what was expected in their write-ups, what vocabulary to be aware of, how to correctly work a procedure, and how to discuss the current material.

These lessons were the bridge to the independent practice. In this time I would start for the first several weeks talking about the rubric, what was expected in their write-ups and how the rubric graded students' abilities to follow those expectations. I did not anticipate beforehand that students would need as much instruction on how to write up the homework as they truly did. Since students never had been asked to write math homework in words, let alone in complete sentences, the assignment requirements seemed to just confuse them and for many was a point of extreme frustration. As I mentioned before over 50% of the class is identified either for SPED or ELL, as well as have a large majority enrolled in the reading program, meaning they are reading at least two grade levels below their grade. Because of their difficulties up front many of the

students wanted to shut down but they continued to work and their perseverance may be more of a reward than anything else.

After homework was assigned the students were to have some class time to start the homework. The intention was for students to look at their work and see if they may have had any questions they may need help with before they went home to work without assistance. With approximately five minutes of classroom time to start their work, the period would be over and so would the majority of the students' academic day.

My intention was to see what would happen to student achievement when students explained their learning in writing, and I found the majority of students who completed their work in complete sentences improved or maintained a high objective assessment average. I only had five of my students who completed the work on a consistent basis, which I considered completing 70% or more of the assignments. I kept track of their assessments from first semester, second semester before the research, the assessment average during the research, the students' average at the completion of the research, and finally for the end of the year.

Three of the students' grades are listed in Figure 1.

	1st Semester Overall Grade	2nd Semester before the research grade	Research data grade	2nd Semester Grade after the research	2nd Semester Overall Grade
Al[1]	91%	92.86%	83.33%	86%	84.80%
Sandy	96.50%	99.64%	94.44%	95.90%	94.80%
Tim	80.20%	86.43%	91.25%	89.90%	88.90%

Figure 1: Spreadsheet of students' scores who completed 70% or more of their homework during the research.

[1] All names are pseudonyms.

Al maintained a high assessment average. Although it did drop, he passed 17 of the 18 objectives during the research. Sandy kept a consistent A the entire year, whether before, during or after the research. The third student, Tim, brought his grade up during the research and was able to maintain the higher grade to end the second semester with a grade 6.7% higher than the end of first semester. His highest average also occurred during the time frame of the research. These grades were welcomed results considering the research occurred during the end of the third quarter until the middle of the fourth quarter, some of the most difficult areas for these students. I expected students' grades to slightly drop or remain steady during the second semester, especially during the period of the research. In this time frame there were many objectives which were new to the students, verses the numerous reviews before this point, especially during first semester.

In the class we frequently discussed the importance of independent practice; we also discussed the purpose of the research and the goal behind it. On March 20, 2009, I wrote in my teaching journal:

> "We did have a discussion on Monday about the homework we have had this quarter and how it has helped us, that it stresses understanding the concepts we are learning and knowing the differences. In our discussions we decided there was a very high level of understanding of the current material. We set a goal as a class to have an average of an 85% or higher on this assessment. In the end there was no assessment less than an 85%, leading us to a discussion that we didn't even have to find the average."

The students were now discussing not only the concepts but their comfort with the material and questioning their own learning.

Once the stress of the change in practice had passed, I noticed more changes in my classroom. Again in my teaching journal, now on April 17, I wrote

> "They are not stressing about the sentences but many are just looking at them as they are intended, just having a conversation with me on paper, telling me why, or how they completed a problem. I am also seeing a correlation between the students who complete their work and who pass their assessments, and how well they pass their assessment. The assessment grades have been very good lately, where the majority or almost all are not just passing but many or in some cases most are earning A's."

The effort the students were making was being displayed in not only higher grades but in the many cases of perfect assessments.

All the intentions and goals were then moot to me in one conversation I had with an ELL student in my classroom. During one of my three interviews, Nate, when asked whether I should continue this activity from my research and do it again next year, told me that I should keep this practice next year because the "sentences help some English Learners get better at writing the language." It was very interesting to find a student appreciate a change in structure to better himself.

The research did not start exactly as I would have planned. At first students did not understand how to write at all, so many just chose not to write anything. Once the students started writing, some were just writing out the steps. While this was a positive move, from not writing to writing, I was looking for the students to express why in their writing. The next hurdle to pass was asking students to write up how they found their solution on identification topics. The students were able to identify what characteristics led them to their classification but there was not as much discussion they could have on these problems. Figure 2 and Figure 3 are

examples of student write-ups for classification. But soon students made a turn and started presenting work with more thought and reason behind their math. In Figure 2, it is easier to see how the students are beginning to explain why in their written solutions, but Figure 3 is an example of when students put many of the pieces together. In the end I did not just want the students to explain why but also use the current terminology to back up the written explanations.

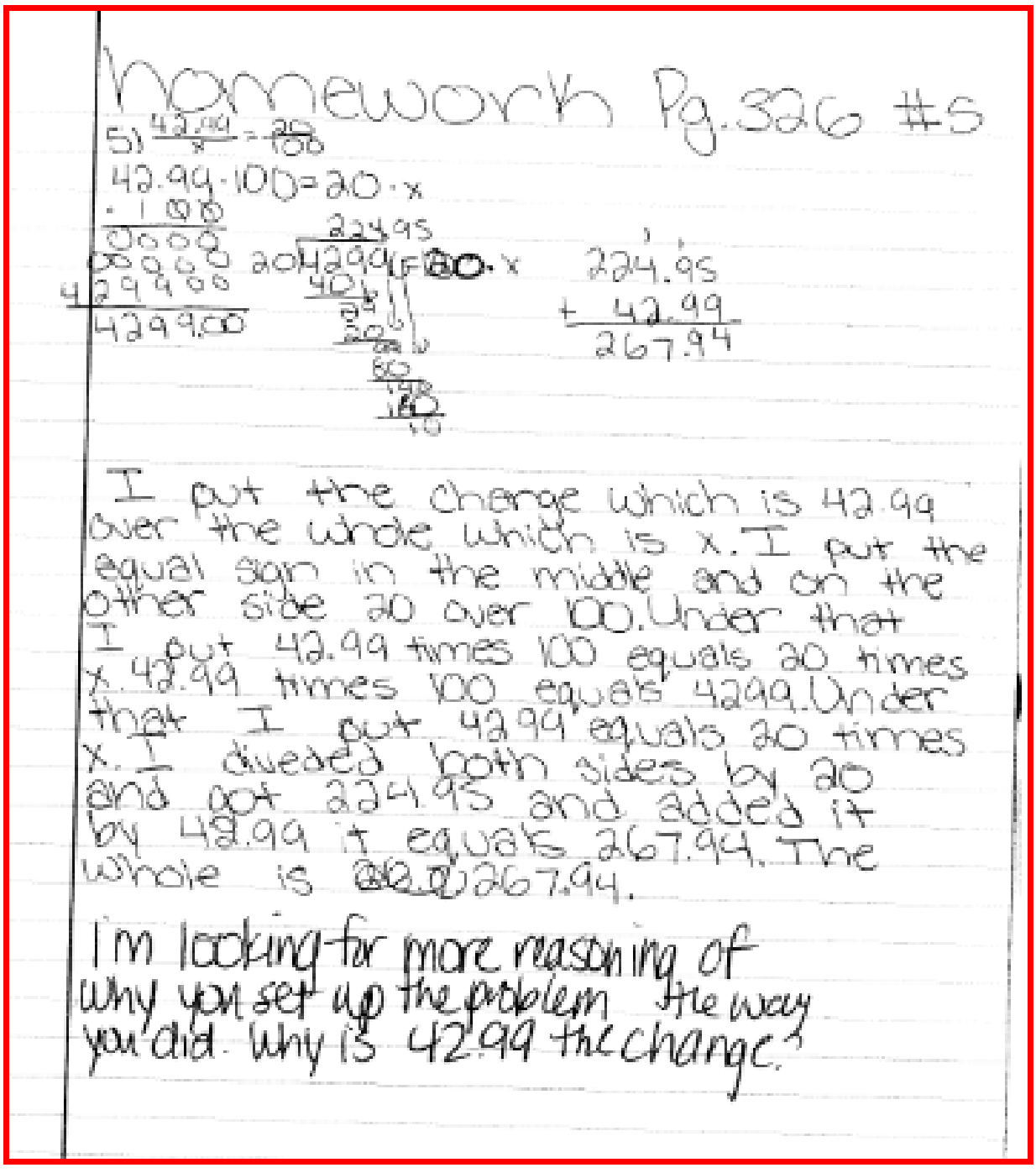


Figure 2: Student explaining their work early in the semester, before having a complete understanding of what is expected of them.

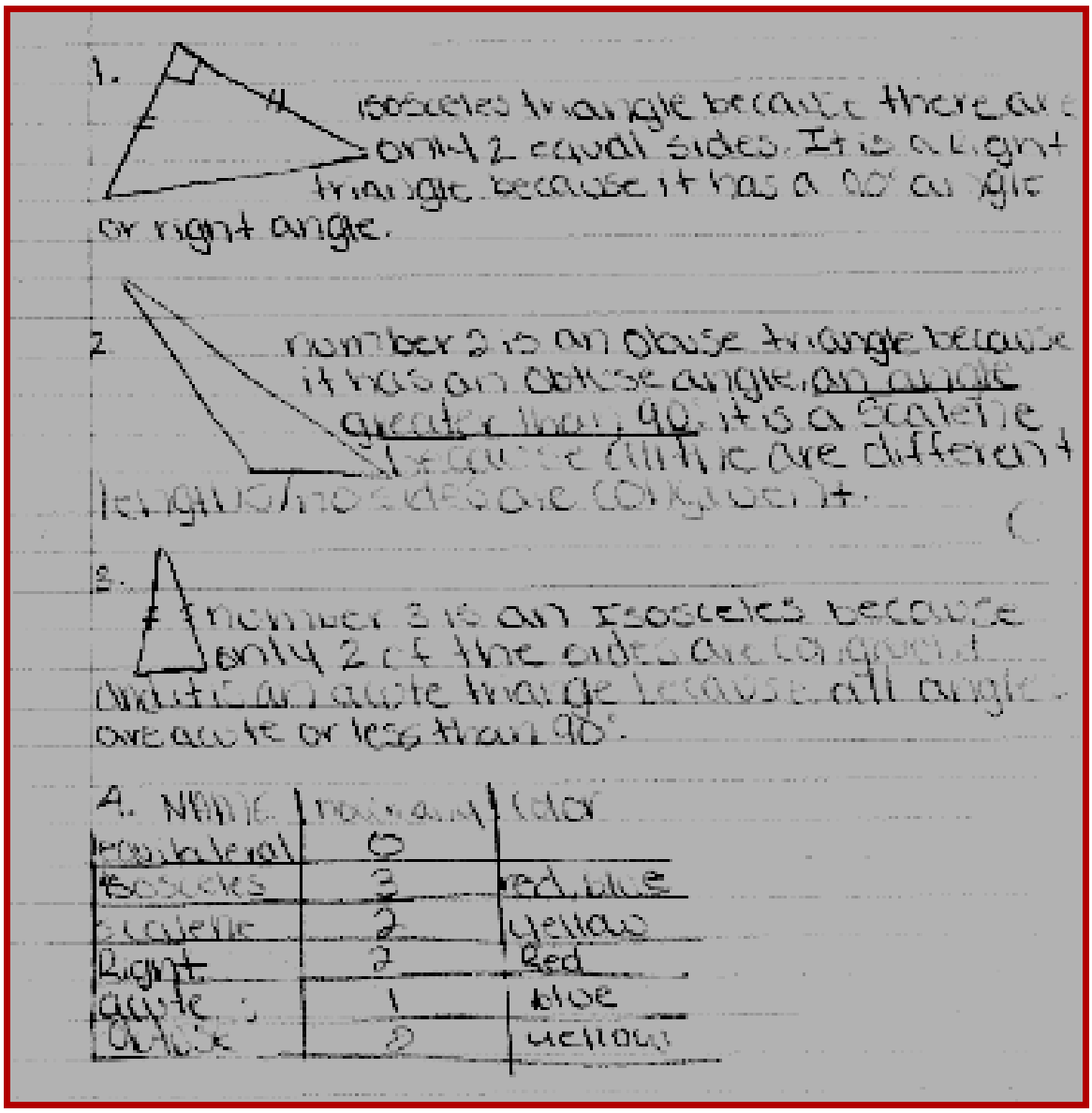


Figure 3: Student writing sentences to explain their math solutions.

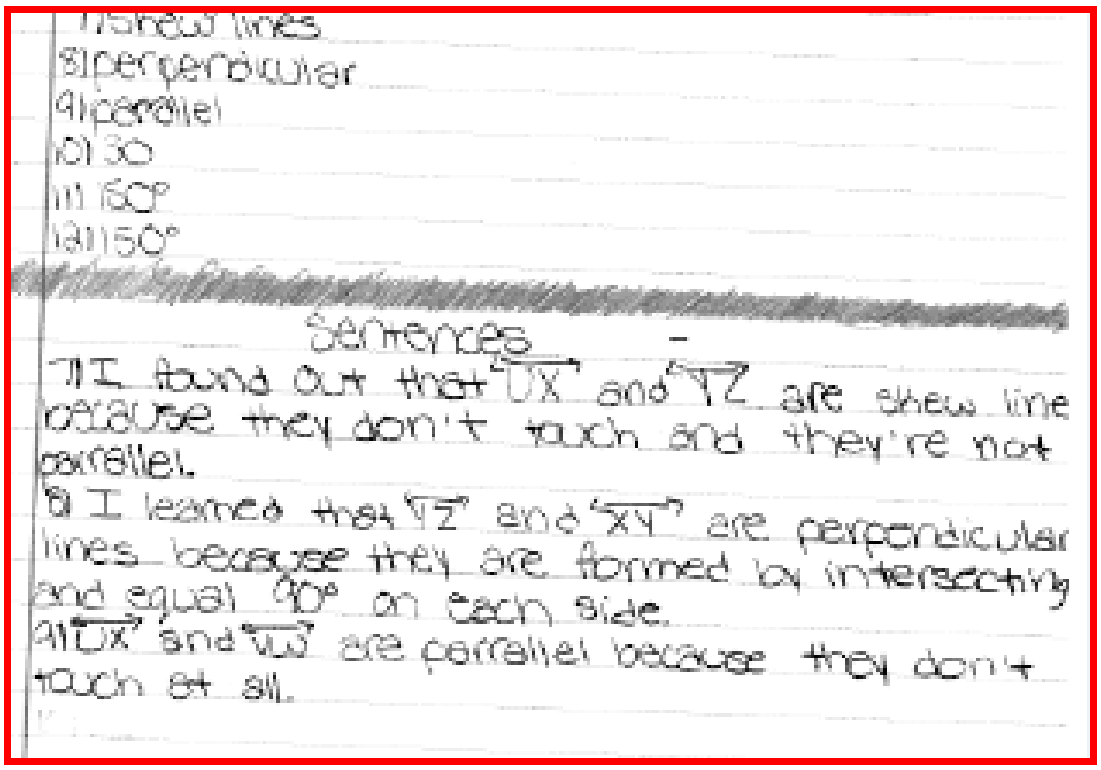


Figure 4: Student writing math homework in complete sentences when there is less detail to the answer.

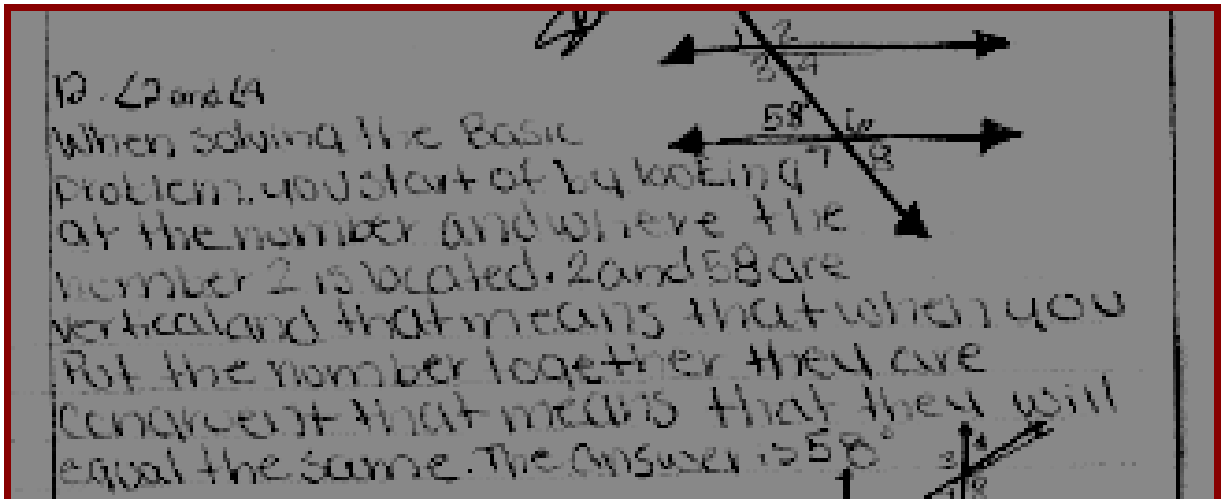


Figure 5: This student is on the border of the ideal explanation, but could use more specific terminology to be successful.

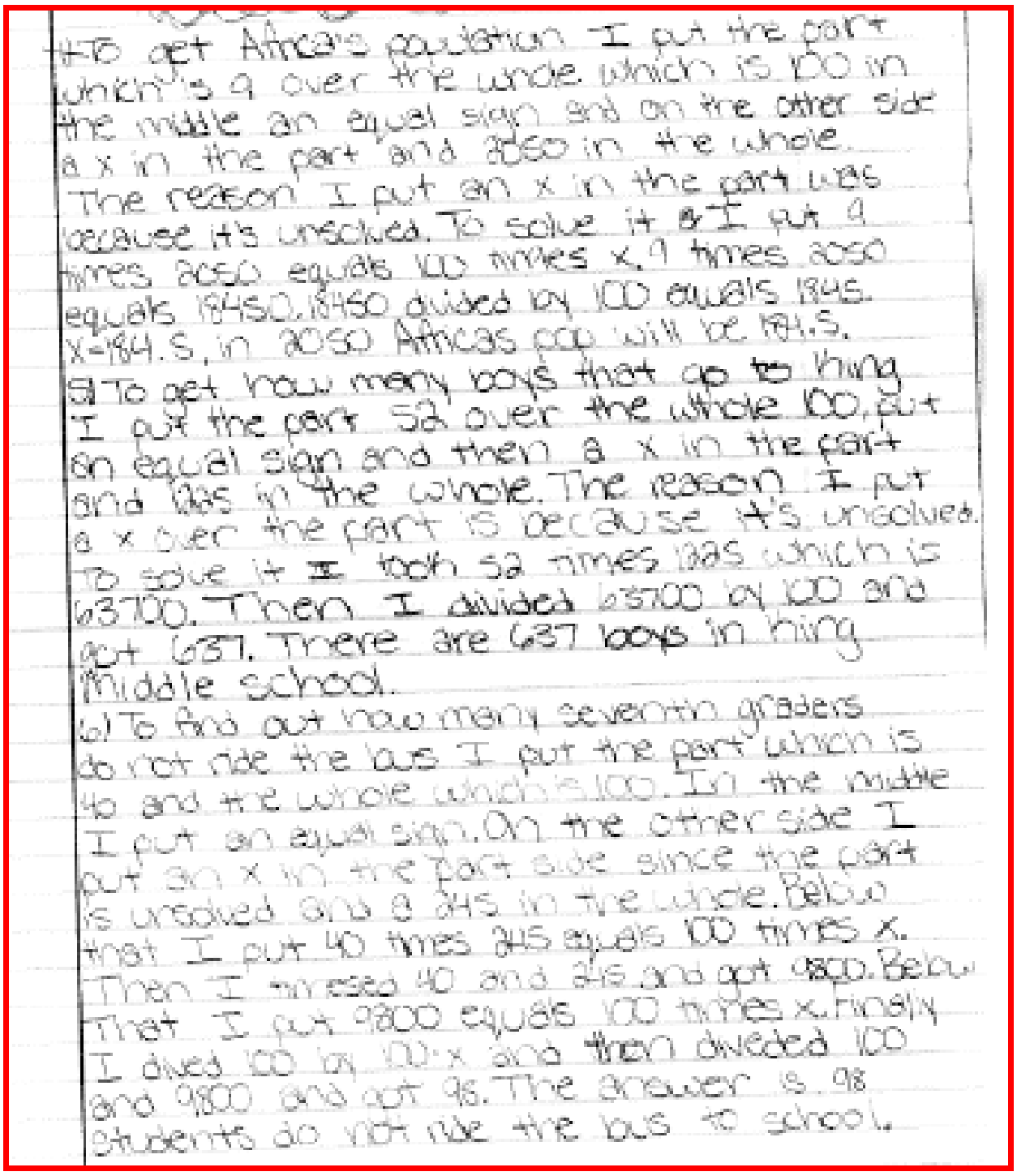


Figure 6: An example of a student expressing the thoughts that went through their mind.

With poor rates of homework completion, and no improvement in that through the research, it was slightly difficult to determine the success for all students in writing sentences.

But since students were asked to give homework presentations whether they had finished the problem or not, I was able to explore the data of all the students to find the success of the presentations. Much like the homework write-ups, the goal of the presentations was to have students explain their understanding of math homework problems. My hope was that students' understanding of the material would improve. I found the majority of students who explained their work correctly and correctly used the current or previous math terminology, or participated in class discussions of the homework, improved or maintained a high objective assessment average.

Since all students were a part of class discussions and participated in homework presentations whether they had completed their homework or not, this data would include all 14 students. Figure 7 gives the data of the variety of grades I kept for students during the research. Three of the five students were ones who completed 70% or more of their work but there are two other students to reflect upon their grades:

	1st Semester Overall Grade	2nd Semester before the research grade	Research data grade	2nd Semester Grade after the research	2nd Semester Overall Grade
Kris	61%	65.71%	68.75%	67.90%	65%
Nate	85.70%	94.29%	91.39%	92.20%	90.40%

Figure 7: Spreadsheet of grade data for a selection of students who participated in classroom discussions during my research.

Of the five students selected out of the total 14, only two were not mentioned in the homework write-ups section. The first, Kris, had her highest grade during the research, and maintained this higher grade for second semester. The other student, Nate, maintained a high assessment grade between a B+ and an A, but a definite increase occurred at the start of research, between first and second semesters.

Changes like Kris and Nate's were seen throughout the research. I noted in my teacher journal on March 13, 2009 stating:

> "The presentations this week were great; the students did a great job of using the terms we have been defining in their write-ups and explanations. I noticed when students were working on homework in the classroom they were taking out the definition sheets and looking at those words and deciding which one applied."

Students like Kris and Nate seemed to adapt the research to increase their understanding of the material.

On April 3, 2009 I noted in my journal:

> "There has been so much conversation on 'why' we do something or how we do it that when I graded their test this week that students didn't just write yes or no they included a sentence why. I was thinking, why didn't I ask why, they all know. I was so excited that the students were so used to telling why that when they were assessed and not even asked why they still told why to reassure themselves they were correct."

These presentations and discussions of 'why' went much further than I had imagined.

The fear that came to my mind when I heard "presentations" was messing up. I did not want to mess up in front of others and be embarrassed, so I would not want to set one of my students up to have that happen to them or for them to have that fear in my class. My first plan was to set up an environment where one could present and make a mistake that we learn from, not embarrass one for making. One student mentioned in an interview talking about the presentations that "we can learn from their (her classmates) mistakes and they can learn from our mistakes." She found it was okay to make a mistake; rather than an embarrassment, it was an opportunity to learn.

The last piece of my research was to see if all students would discover the same way to find a correct answer. My research led me to the area of problem solving. I thought in my class students were able to better understand the idea of math and the concepts when they saw there were multiple methods to solve one problem correctly.

This was one of the first results I saw from the class discussions, in my journal on February 27, 2009 I wrote:

> "A student in their presentation discussed changing a fraction to a percent by first using what already knew from a previous objective by dividing the numerator by the denominator to find the decimal. Then using another new concept but one that was not as difficult, changing from a decimal to a percent you multiply by 100. They took two concepts they understood better to correctly solve the same problem."

Students can now find ways to connect new material to others they already know, rather than learning a completely new strategy.

There was also a quick connection to the problem solving, like my research had discovered. In another journal from February 27, 2009, I wrote:

> "When they asked to find how many students did not ride the bus if 60% rode the bus. Rather than finding the 60% then deciding this is the group you don't want to use then subtract from the whole to find the number of students that did not ride the bus. But he started the problem by first saying if 60% ride the bus and there is 100% so then 100-60 or 40% of the students do not ride the bus and then he just found the number of students for 40%."

Part of real-life math and problem solving is ensuring one is answering the question asked. This student did a great job of not only ensuring they answered the question but they were able to explain this and their solution of why to their classmates.

In my interviews I had several students mention that they liked hearing a different way of solving a problem. One student said:

> "If someone else is presenting you can learn from that person, maybe they did it one way and you did it a different way. Then you can learn a new way, and if they do a faster way, you can learn a faster way to do it."

This was reiterated throughout the interviews with numerous students saying it helps one learn new ways to solve a problem.

The new ways also helped me as a teacher, so times when one has understood a concept for a period of time it is harder to look at it from the point of view of how one would be confused. In my March 13, 2009, journal I wrote:

> "I had a student that sees straight angles when they make a horizontal line verses a vertical line so he found the vertical angle then found the missing angle because it was supplementary to the first angle. It could have first been supplementary to the original angle but they struggled seeing this because it was vertical. This was an interesting thing to find out about one of my students, this is a struggle I would have never thought of but it really helped others to see his thoughts on solving too."

This student helped me remember to look back and try to learn the concept from a student's point of view to stress the connections and differences so students better understand new concepts.

In choosing this topic I wanted students to have a better grasp on learning, and also wanted students to put more thought in their independent practice. Before my research the homework completion rate was very low; the completion rate for before the research was 65.3%, as show in Figure 8. I wanted to give students the view that homework was beneficial, and while improving learning, I was also hoping to improve their homework completion. In the end I found students felt more comfortable with the new learning strategy when I took time to explain the rubric and explain the thought process I spend in solving a problem. I did not find that the students had time in the research to increase their homework completion. The first thing I learned from this research is that I needed to teach any concept I want presented. With the use of writing in complete sentences in my building, and grading with rubrics I did not anticipate this being such a struggle. I found a very significant need for teaching the students explicitly what was expected of them in write-ups and in the class presentations. I discussed this surprise in my journal on February 20, 2009: “I feel like I am settling fires or fielding explanations of what the homework is actually supposed to be rather than really being able to use.” I thought we would go through the rubric, do an example and the students would be able to try a solution on their own. I was not expecting perfection, just a conversation on paper, but this was so different than anything they had done before there was a real struggle of not only “how” but “why.”

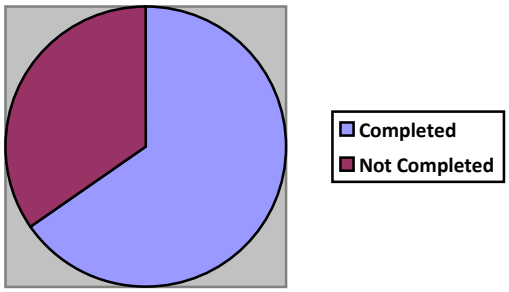


Figure 8. This represents the homework completion rate, during second semester but before the research.

The hardest struggle was to recover the research after a poor start. In more of my journal from February 20, 2009, I wrote:

> "I created such confusion by not presenting the new expectations in a clearer format that I have students not motivated to do their homework even more than they had before the project, causing the reverse reaction I was hoping for. I just wish I could start this all over and think more about the path to get to my goal and less about my goal at the end. I know too much of my focus was on if they can explain the material they would develop a better understanding of the material, so I wanted them to explain the problems, then I knew they would be less likely to want to complete their work if they had huge amounts of work so I thought I would be selective and pick problems that would show me their understanding of the material and allow them to explain themselves. But I did not have enough focus on preparing them for the change, I did not do this in a clear enough format. In making the assumption they knew what a complete sentence was and they knew the math terms we have been using I thought they understood their directions."

My fear at this point was I had caused more confusion for the students, rather than improving their learning.

The confusion I was seeing was being reflected in the students' homework completion. Also in my February 20, 2009, journal I wrote:

> "Right now after first assigning the change, homework completion is going down. I have students who have turned in their homework everyday but the expectations confused them; they were not clear and this unmotivated them. My fear is I created this

> unmotivation that won't just turn back on that I will have to spend a great deal of time to bring these students back."

At this point I had students who were previously very good at completing their homework and now were coming to class completely unprepared and unmotivated to complete their independent practice.

In my March 6, 2009, journal I talked about how I was trying to fix the students' feelings of homework and get them back on track. I wrote:

> "I decided this week since there were so many students who had struggled with what I was expecting of the homework write-ups we would do an exercise together. We split the class into three groups and gave each group a different story problem. The groups then discussed the problem together, what they think they need to do to solve it. After solving the problem they did a group write-up and discussed what terms (vocabulary) they should use and explained it to each other to be able to convert their methods to paper explanation."

This activity really helped the students see what was expected, and talk it through with a classmate rather than asking me for guidance. Doing this as a group seemed to make them more comfortable in what was being asked of them.

Finally, in my March 20, 2009, journal I started to notice their attitudes turn around. In this journal I wrote "they are finally seeing the concept behind the sentences is very beneficial, they don't really enjoy the sentences but they find they help them better understand the concepts, in turn improving their learning." I wrote more about this in my April 10, 2009, journal stating "students are seeing that they are accountable for their homework, they also see that completing

the practice makes a difference in their outcome of learning. They are finally starting to put back some of that effort and try more."

In the end, although my plan did not go as well as I had hoped, students did improve their homework throughout the research, but dropped from before the research. The students who completed their assignments dropped from the 65.3% to the 52.7% during the research as shown in Figure 9. But those were the students who turned in some form of an assignment; only 34.6% as shown in Figure 10, completed the homework in complete sentences as asked. While the homework completion rate did not go up, it did require me to give more focus on independent practice for students during the class period so the first time they try a problem on their own would not be during their summative assessment.

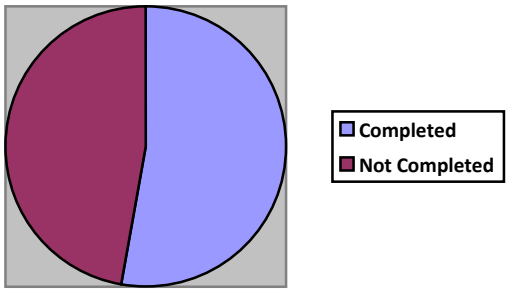


Figure 9. This represents the homework completion rate during the research.

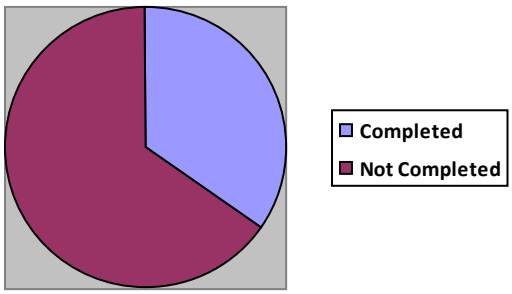


Figure 5. This represents the homework completion rate of complete sentences during the research.

Conclusions

Looking back at the past 10 weeks the changes in the classroom atmosphere were greater than the changes shown in the data. I witnessed the comfort of students rise in the study of math. This was seen through their writing, presenting, discussions, and interviews. The homework completion was not affected, so it was hard to see if the sentences really affected the learning, all the students were still involved in the presentations and class discussions, where I believe one would see the greatest outcome.

Burton and Morgan (2000) stated "in the educational context, students at many levels find writing difficult and may not communicate their mathematical thinking effectively" (p. 430). I did find this to be true: the change from mathematical thinking to grammatical thinking was very difficult for some students and due to their eagerness to be perfect they struggled having a written conversation, explaining what thoughts where in their mind when they were solving. Many students were used to one correct answer, one way of doing it, and this change was what was throwing them off.

Besides writing their homework in complete sentences students were also asked to then come the following day and present their homework before the class. Pugalee (2004) found when most student strategies were the same, there was a higher probability of student success, but when there are a variety of strategies, there is a higher probability of student mistakes. This may seem to be true in this study but Pugalee gave these mistakes a negative feeling while the students in this research seemed to embrace mistakes. Mistakes did not throw off student learning, but rather students saw there were others making the same mistakes and seeing where the mistakes were coming from.

Overall, the students embraced the change. While they may not have completed their work, they seemed to allow themselves to engage in mathematical discussions for verification. They were no longer dependent on a rule but would look for cues and for definitions and their thought process to help lead their way.

Implications

In the future I will find the middle ground; the project seemed to be a complete success but yet somewhat overkill. Trying to having plenty of data, the students were writing sentences for every homework assignment, when these strategies truly fit best in some areas better than others. Next year the plan is to include these all throughout the year, but in more purposeful spots of the curriculum, rather than for every assignment as I did for my research. I also plan to continue the presentations to help students express their understanding, view new methods and be proud of their mathematical ability. Assessments will change in some areas to ask more of the students, probe their thinking, and expect their true knowledge, not rote memory. The discussions of the concepts, the vocabulary, and the skills will continue to help the students better understand the current skills. The question of why, however, will appear all year long in all they do. This is the purpose behind learning, not to remember or to practice but to know why, because understanding why creates a strong building block on which to build.

In my building, which failed the state requirements for No Child Left Behind last year, writing has been a very important role in learning across curriculum. I think there are teachers who struggle to find a way to incorporate writing in their lessons, but I also believe some of the struggle is with their inner selves because they do not really think it will benefit. I will share with my co-workers what writing and talking did to improve the learning of the students I instructed.

References

Bryan, T. & Sullivan-Burstein, K. (1998). Teacher-selected strategies for improving homework completion. *Remedial and Special Education, 19*(5), 263-275.

Burton, L. & Morgan, C. (2000). Mathematicians writing. *Journal for Research in Mathematics Education, 31*(4), 429-453.

Charles, R. & Lester Jr, F. (1984). An evaluation of a process-oriented instructional program in mathematical problem solving in grades 5 and 7. *Journal for Research in Mathematics Education, 15*(1), 15-34.

Clarke, D., Waywood, A. & Stephens, M. (1993). Probing the structure of mathematical writing. *Educational Studies in Mathematics, 25*(3), 235-250.

Lubienski, S. (2000). Problem solving as a means towards mathematics for all: an exploratory look through a class lens. *Journal for Research in Mathematics Education, 31*(4), 454-482.

Mosenthal, J. (1995). Change in two teachers' conceptions of math or writing instruction after in-service training. *The Elementary School Journal, 95*(3), 263-277.

Pugalee, D. (2004). A comparison of verbal and written description of students' problem solving processes. *Educational Studies in Mathematics, 55*(1/3), 27-47.

Shield, M. & Galbraith, P. (1998). The analysis of student expository writing in mathematics. *Educational Studies in Mathematics, 36*(1), 29-52.

Appendix A

Grading rubric

Writing portion

3 points	2 points	1 point
Student wrote responses in complete sentences	Student wrote responses in mostly complete sentences. Student wrote responses beyond the math problems.	Student only solved the problems with no complete sentences.
3 points	2 points	1 point
Student explained each step they did in detail. Student fully explained what they were thinking when they were solving the problems.	Student explained most steps they did. Students shared some of what they were thinking when solving these problems.	Student let the numbers explain themselves, with little or no written explanation. Student did not share what they were thinking when they were solving these problems.
3 points	2 points	1 point
Student correctly used math concepts and vocabulary to explain their answer.	Students used some or tried to use math concepts and vocabulary to explain their answer.	Students did not use math concepts or vocabulary to explain their answer.
3 points	2 points	1 point
Students correctly used current lessons to solve these problems.	Students use some or tried to use current lessons to solve these problems.	Student did not use current lessons to solve these problems.

Appendix B

Presentation portion

3 points	2 points	1 point
Student discussed what they were thinking when they were solving the problems in their presentation.	Student discussed some of what they were thinking when they were solving the problems in their presentation.	Student did not discuss what they were thinking when they were solving the problems in their presentation.
3 points	2 points	1 point
Students correctly used math concepts and vocabulary in their presentation.	Students used some or tried to use math concepts and vocabulary in their presentation.	Student did not use math concepts or vocabulary in their presentation.
3 points	2 points	1 point
Students correctly used current lessons in presentation.	Student used some or tried to use current lessons in presentations.	Student did not use current lessons in presentation.

Appendix C

Homework before research
From 1/21/09 until 2/13/09

Number of assignments 7

Assignment 1

Number of students completing work	11
Number of students not completing the work	3
Number of students excused	2
Percentage of homework assignment completed	11/14 or 78.6%
Completed Assignment average	84.8%

Assignment 2

Number of students completing work	11
Number of students not completing the work	3
Number of students excused	2
Percentage of homework assignment completed	11/14 or 78.6%
Completed Assignment average	90.9%

Assignment 3

Number of students completing work	10
Number of students not completing the work	4
Number of students excused	2
Percentage of homework assignment completed	10/14 or 71.4%
Completed Assignment average	75%

Assignment 4

Number of students completing work	11
Number of students not completing the work	3
Number of students excused	2
Percentage of homework assignment completed	11/14 or 78.6%
Completed Assignment average	84.8%

Assignment 5

Number of students completing work	5
Number of students not completing the work	9
Number of students excused	2
Percentage of homework assignment completed	5/14 or 35.7%

Completed Assignment average	76.7%	
Assignment 6		
Number of students completing work	9	
Number of students not completing the work	5	
Number of students excused	2	
Percentage of homework assignment completed	9/14 or 64.3%	
Completed Assignment average	92.6%	
Assignment 7		
Number of students completing work	7	
Number of students not completing the work	7	
Number of students excused	2	
Percentage of homework assignment completed	7/14 or 50%	
Completed Assignment average	88.1%	
Overall homework completion from 1/21/09 to 2/13/09	64/98	65.3%

Appendix D

Assignments during research
From 2/16/09 to 4/17/09

Number of assignments 22

2/18/09 Assignment 1

No late assignments were accepted, it was graded by who completed their work and who did not.

Number of students completing work	2
Number of students not completing the work	7
Number of students excused	7
Percentage of homework assignment completed	2/7 or 28.6%
Completed Assignment average	100%

2/19/09 Assignment 2

Number of students completing work	10
Number of students not completing the work	4
Number of students excused	2
Percentage of homework assignment completed	10/14 or 71.4%
Completed Assignment average	65%

2/23/09 Assignment 3

Problems explained in complete sentences

Number of students completing work	9
Number of students not completing the work	6
Number of students excused	1
Percentage of homework assignment completed	9/15 or 60%
Completed Assignment average	59.3%

2/24/09 Assignment 4

No work explained in complete sentences

Number of students completing work	8
Number of students not completing the work	7
Number of students excused	1
Percentage of homework assignment completed	8/15 or 53.3%
Completed Assignment average	91.7%

2/26/09 Assignment 5

	Completed work and story problems as a group	
Number of students completing work		15
Number of students not completing the work		0
Number of students excused		1
	Percentage of homework assignment completed	15/15 or 100%
	Completed Assignment average	91.1%

2/26/09	Assignment 6	
Number of students completing work		7
Number of students not completing the work		8
Number of students excused		1
	Percentage of homework assignment completed	7/15 or 46.7%
	Completed Assignment average	100%

2/27/09	Assignment 7	
Number of students completing work		6
Number of students not completing the work		9
Number of students excused		1
	Percentage of homework assignment completed	6/15 or 40%
	Completed Assignment average	97.2%

3/3/09	Assignment 8	
Number of students completing work		8
Number of students not completing the work		8
Number of students excused		0
	Percentage of homework assignment completed	8/16 or 50%
	Completed Assignment average	97.9%

3/4/09	Assignment 9	
Number of students completing work		8
Number of students not completing the work		7
Number of students excused		1
	Percentage of homework assignment completed	8/15 or 53.3%
	Completed Assignment average	87.5%

	Problems in complete sentences	
Number of students completing work		3
Number of students not completing the work		12
Number of students excused		1
	Percentage of homework assignment completed	3/15 or 20%

	Completed Assignment average	69.4%
3/5/09	Assignment 10	
	Number of students completing work	8
	Number of students not completing the work	8
	Number of students excused	0
	Percentage of homework assignment completed	8/16 or 50%
	Completed Assignment average	95.8%
3/5/09	Assignment 11	
	Number of students completing work	9
	Number of students not completing the work	7
	Number of students excused	0
	Percentage of homework assignment completed	9/16 or 56.25%
	Completed Assignment average	98.1%
3/9/09	Assignment12	
	Number of students completing work	6
	Number of students not completing the work	10
	Number of students excused	0
	Percentage of homework assignment completed	6/16 or 37.5%
	Completed Assignment average	52.8%
3/11/09	Assignment 13 in complete sentences	
	Number of students completing work	6
	Number of students not completing the work	10
	Number of students excused	0
	Percentage of homework assignment completed	6/16 or 37.5%
	Completed Assignment average	65.3%
3/31/09	Assignment 14	
	Number of students completing work	6
	Number of students not completing the work	8
	Number of students excused	2
	Percentage of homework assignment completed	6/14 or 42.9%
	Completed Assignment average	100%
	Problems explained in complete sentences	
	Number of students completing work	6
	Number of students not completing the work	8

	Number of students excused	2
	Percentage of homework assignment completed	6/14 or 42.9%
	Completed Assignment average	84.7%
4/1/09	Assignment 15	
	Number of students completing work	7
	Number of students not completing the work	7
	Number of students excused	2
	Percentage of homework assignment completed	7/14 or 50%
	Completed Assignment average	95.2%
	Problems explained in complete sentences	
	Number of students completing work	7
	Number of students not completing the work	7
	Number of students excused	2
	Percentage of homework assignment completed	7/14 or 50%
	Completed Assignment average	91.7%
4/1/09	Assignment 16	
	Number of students completing work	6
	Number of students not completing the work	8
	Number of students excused	2
	Percentage of homework assignment completed	6/14 or 42.9%
	Completed Assignment average	100%
	Problems explained in complete sentences	
	Number of students completing work	4
	Number of students not completing the work	10
	Number of students excused	2
	Percentage of homework assignment completed	4/14 or 28.6%
	Completed Assignment average	95.8%
4/2/09	Assignment 17	
	Number of students completing work	7
	Number of students not completing the work	7
	Number of students excused	2
	Percentage of homework assignment completed	7/14 or 50%
	Completed Assignment average	97.6%
	Problems explained in complete sentences	

Number of students completing work	7
Number of students not completing the work	7
Number of students excused	2
Percentage of homework assignment completed	7/14 or 50%
Completed Assignment average	67.3%

4/3/09 Assignment 18

Number of students completing work	7
Number of students not completing the work	7
Number of students excused	2
Percentage of homework assignment completed	7/14 or 50%
Completed Assignment average	100%

4/7/09 Assignment 19

Number of students completing work	7
Number of students not completing the work	7
Number of students excused	2
Percentage of homework assignment completed	7/14 or 50%
Completed Assignment average	86.9%

Problems explained in complete sentences

Number of students completing work	4
Number of students not completing the work	10
Number of students excused	2
Percentage of homework assignment completed	4/14 or 28.6%
Completed Assignment average	56.3%

4/8/09 Assignment 20

Number of students completing work	5
Number of students not completing the work	9
Number of students excused	2
Percentage of homework assignment completed	5/14 or 35.7%
Completed Assignment average	91.7%

Problems explained in complete sentences

Number of students completing work	3
Number of students not completing the work	11
Number of students excused	2
Percentage of homework assignment completed	3/14 or 21.5%
Completed Assignment average	84.7%

4/13/09	Assignment 21		
	Number of students completing work	11	
	Number of students not completing the work	3	
	Number of students excused	2	
	Percentage of homework assignment completed	11/14 or 78.6%	
	Completed Assignment average	94.7%	
	Problems explained in complete sentences		
	Number of students completing work	7	
	Number of students not completing the work	7	
	Number of students excused	2	
	Percentage of homework assignment completed	7/14 or 50%	
	Completed Assignment average	88.1%	
4/14/09	Assignment 22		
	Number of students completing work	9	
	Number of students not completing the work	5	
	Number of students excused	2	
	Percentage of homework assignment completed	9/14 or 64.3%	
	Completed Assignment average	88.9%	
	Problems explained in complete sentences		
	Number of students completing work	3	
	Number of students not completing the work	11	
	Number of students excused	2	
	Percentage of homework assignment completed	3/14 or 21.4%	
	Completed Assignment average	79.2%	
Overall homework completion from 2/16/09 to 4/17/09		167/317	52.7%
Overall complete sentences completion from 2/16/09 to 4/17/09		44/127	34.6%

Appendix E

Formative Assessment results before the research

Quiz 1 Class average for the quiz was 71.4%

Quiz 1 Class median for the quiz was 67%

Quiz 2 Class average for the quiz was 77.4 %

Quiz 2 Class median for the quiz was 100%

Appendix F

Summative Assessment results before the research

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Average (%)	84.5	76.6	86.4	68.6	58.6	83.2	71.1
Standard Deviation	26.4	27.9	19.5	28.4	38.1	23.3	30.6
Median (%)	92.5	83.8	88.8	75	60	100	75

Above lists the averages for each of the seven assessments before the research…
When the seven "averages" are averaged it is 75.6%
Standard deviation 10.1
The median of the seven "averages" is 76.6%
Above lists the medians for each of the seven assessments before the research…
When the seven "medians" are averaged it is 82.2
Standard deviation 13.3
The median of the seven "medians" is 83.8%

Appendix G

Formative Assessment results during the research

Quiz Class Average for the quiz was 38%

Standard deviation 35.3

Quiz 1 Class Median for the quiz was 40%

Quiz 2 Class Average for the quiz was 50%

Standard deviation 51.9

Quiz 2 Class Median for the quiz was 50%

Quiz 3 Class Average for the quiz was 18.2%

Standard deviation 32.8

Quiz 3 Class Median for the quiz was 0%

Appendix H

Summative Assessment results during the research

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
Mean (%)	73.2	80.5	74.5	59.3	90.9	78.8	86.6	94.5	88.9
Standard Deviation	19.5	26.9	29.5	34	11.9	13.4	22.9	3.3	25.5
Median (%)	75.5	90	88.8	70	100	80	92.5	95	100
	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15	Test 16	Test 17	Test 18
Mean (%)	79.6	73.6	91.1	86.4	75.7	85	89.6	82.3	98
Standard Deviation	18.1	34.2	12	13.9	24.6	11.4	15.2	13	4.6
Median (%)	87.5	95	97.5	90	87.5	87.5	100	85	100

Above lists the averages for each of the 18 assessments during the research…
When the 18 “averages” are averaged it is 82.7%

Standard deviation 9.4

The median of the 18 “averages” is 83.7%

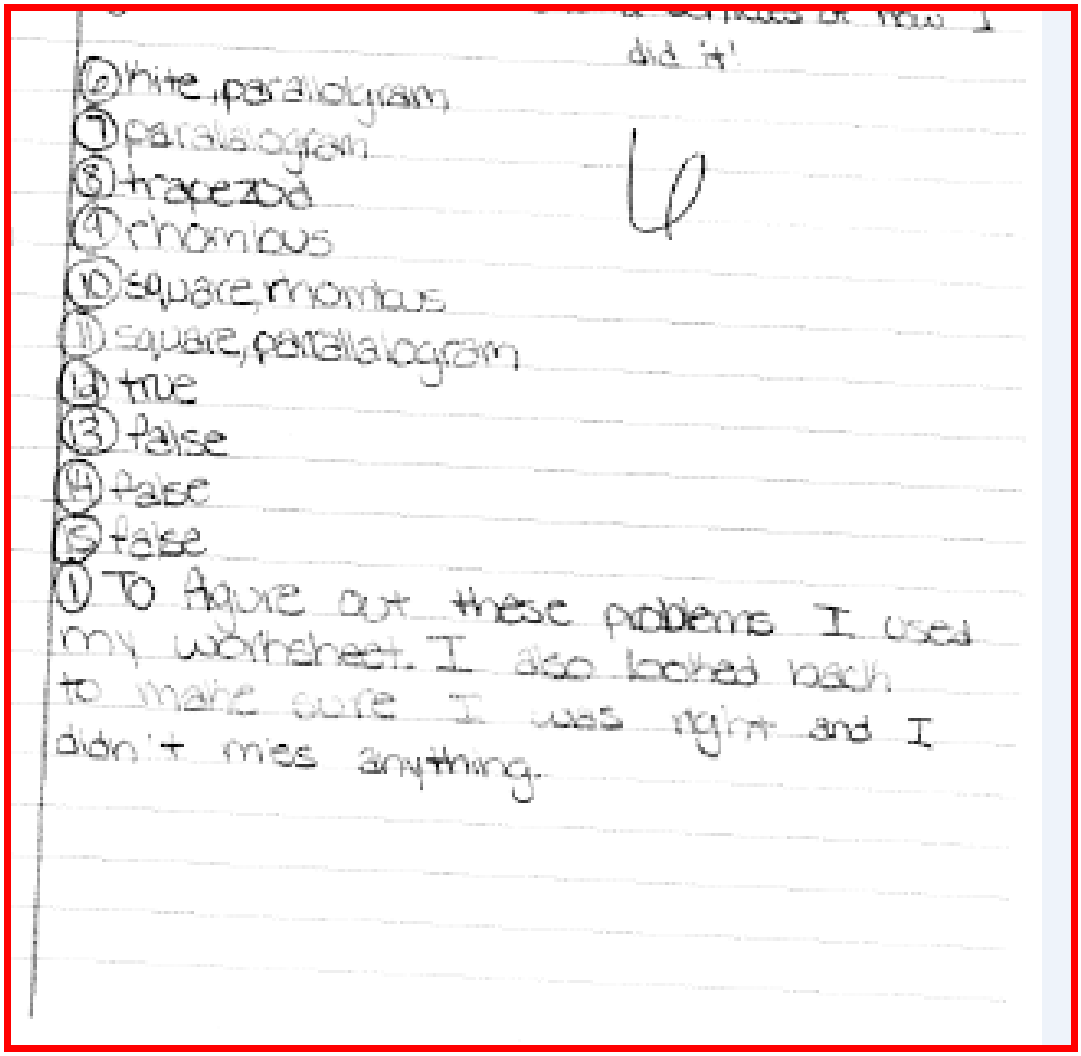
Above lists the median for each of the 18 assessments before the research…
When the 18 “medians” are averaged it is 90.1%

Standard deviation 8.6

The median of the 18 “medians” is 90%

Appendix I

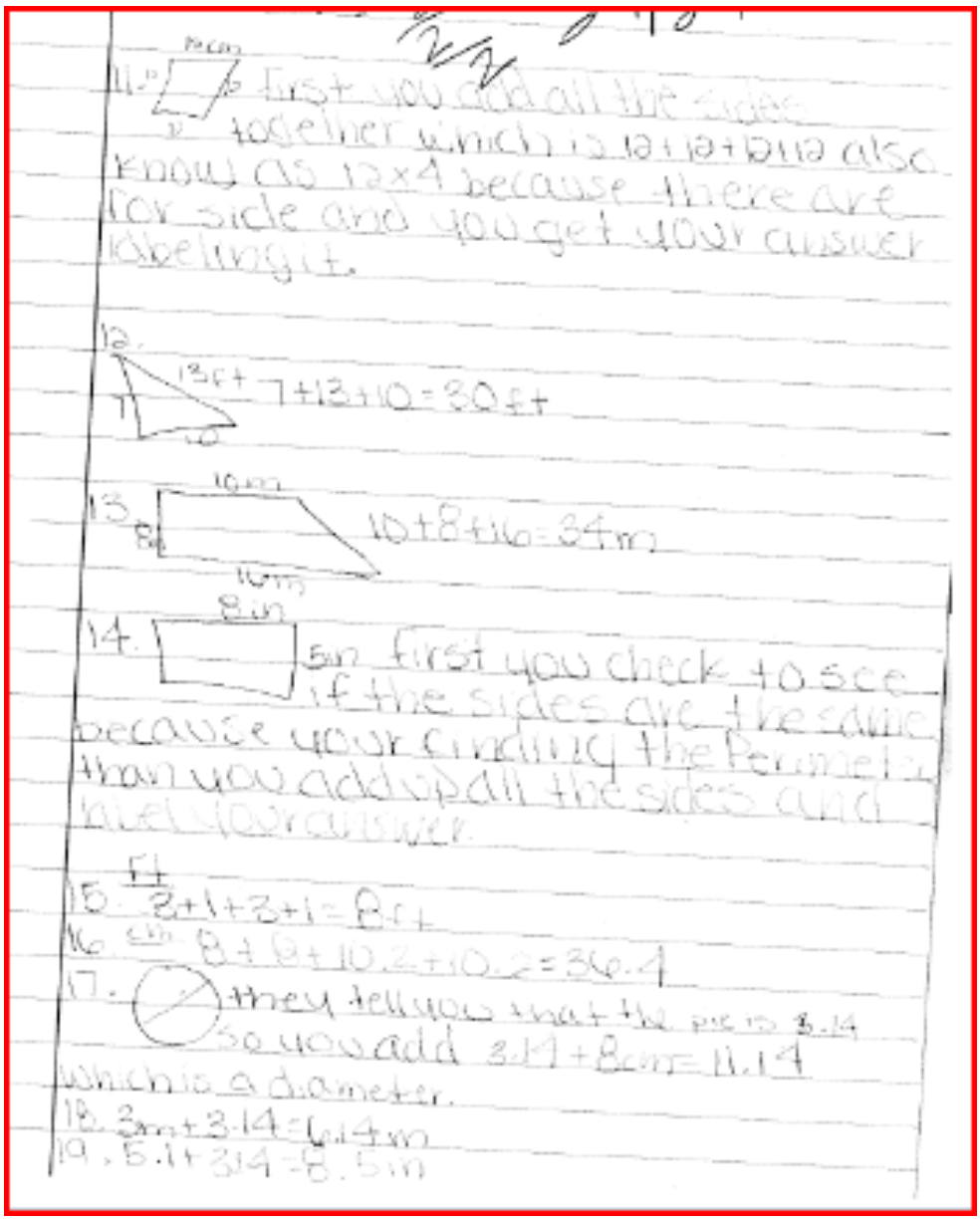
"make copies of student work, formative and summative assessments, homework, graded rubrics"

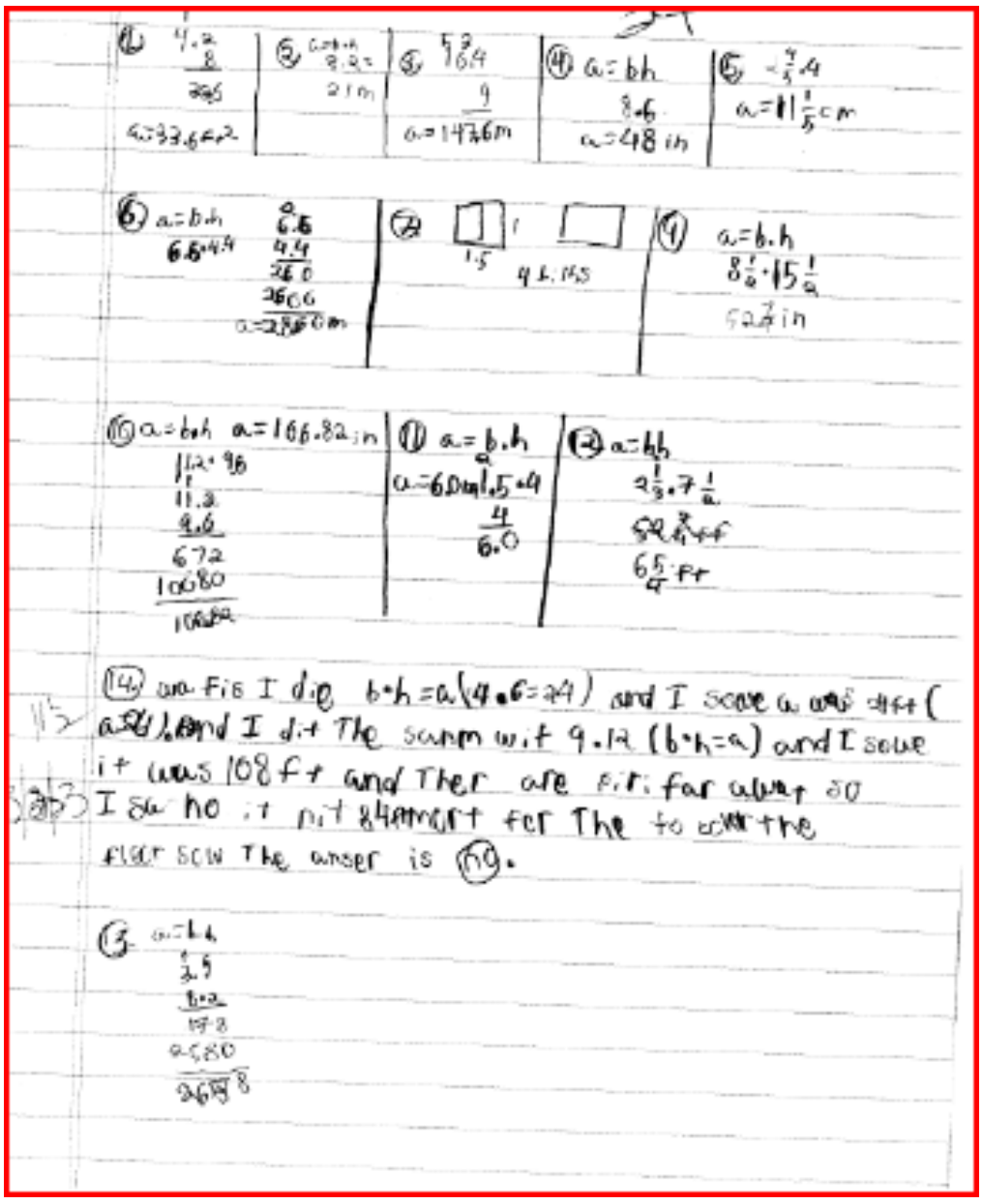


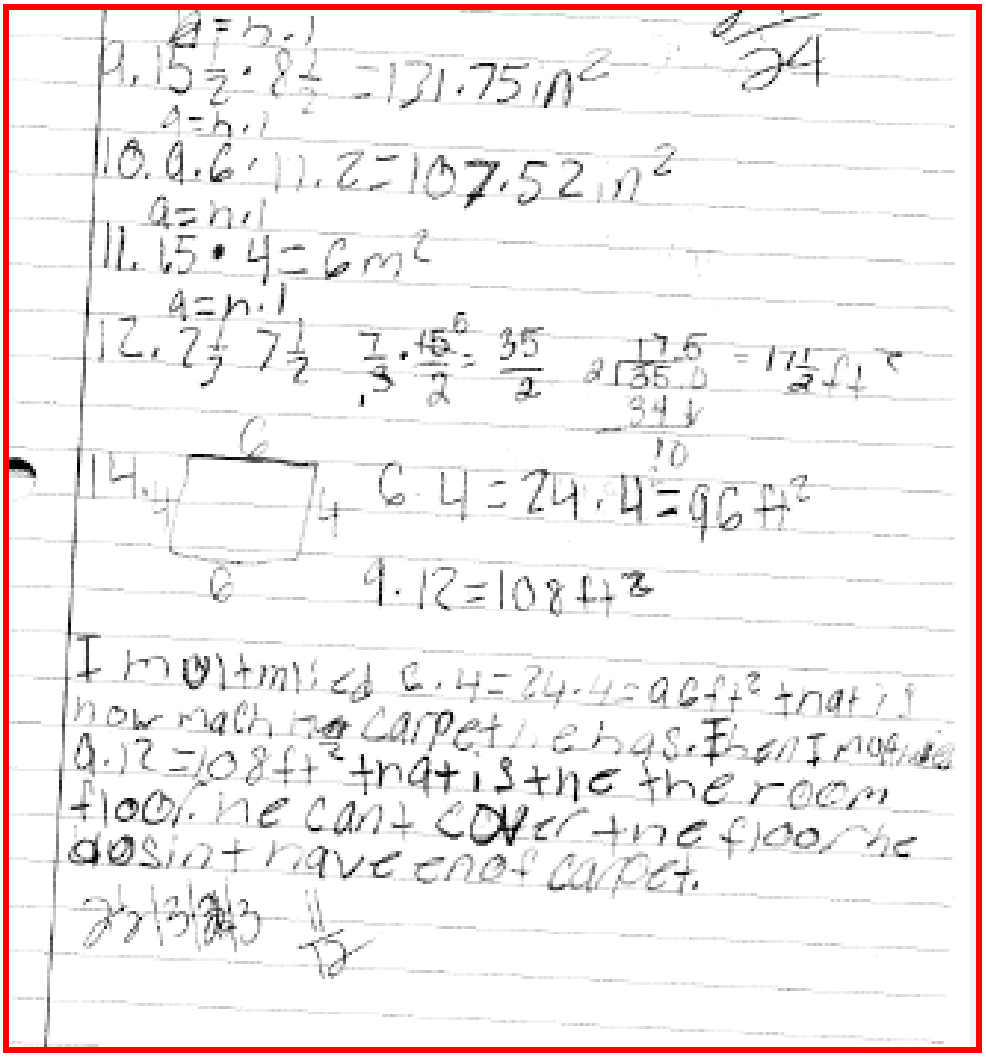
did it'

6 rhombus, parallelogram
7 parallelogram
8 trapezoid
9 rhombus
10 square, rhombus
11 square, parallelogram
12 true
13 false
14 false
15 false

To figure out these problems I used my worksheet. I also looked back to make sure I was right and I didn't miss anything.


11. 12 inch
First you add all the sides together which is 12+12+12+12 also know as 12x4 because there are for side and you get your answer labeling it.
12. 13cm
7+13+10=30cm
13. 10cm
8cm
10cm
10+8+16=34m
14. 8in
5in first you check to see if the sides are the same because your finding the Perimeter than you add all the sides and label your answer.
15. 5ft
2+1+3+1=8ft
16. 8+8+10.2+10.2=36.4
17. they tell you that the pie is 3.14 so you add 3.14+8cm=11.14 which is a diameter.
18. 3m+3.14=6.14m
19. 5.1+3.4=8.5in


4.2
8
336
a=33.6 ft2
21 in
9.2=
5 3/4
9
a=14.76 m
a=bh
8.6
a=48 in
a=11 1/5 cm
a=b.h
6.5
4.4
260
2600
a=28.60 m
1.5
a=b.h
8 1/2 · 15 1/2
a=bh a=166.82 in
12.98
11.3
9.6
672
10080
a=b.h
a=60 in 1.5 · 4
4
6.0
a=bh
2 1/3 · 7 1/2
65/4 ft
(14) an Fis I did b·h=a(4.6=24) and I solve a was 24ft (and I did the same wit 9.12 (b·h=a) and I solve it was 108 ft and ther are 5 ft far away so I sa no it isnt 84meter for the to the floor sow the answer is no.
(3) a=b.h
3.9
6.2
78
2340
2418



9. $15\frac{1}{2} \cdot 8\frac{1}{2} = 131.75 in^2$

10. $9.6 \cdot 11.2 = 107.52 in^2$

11. $15 \cdot 4 = 6 m^2$

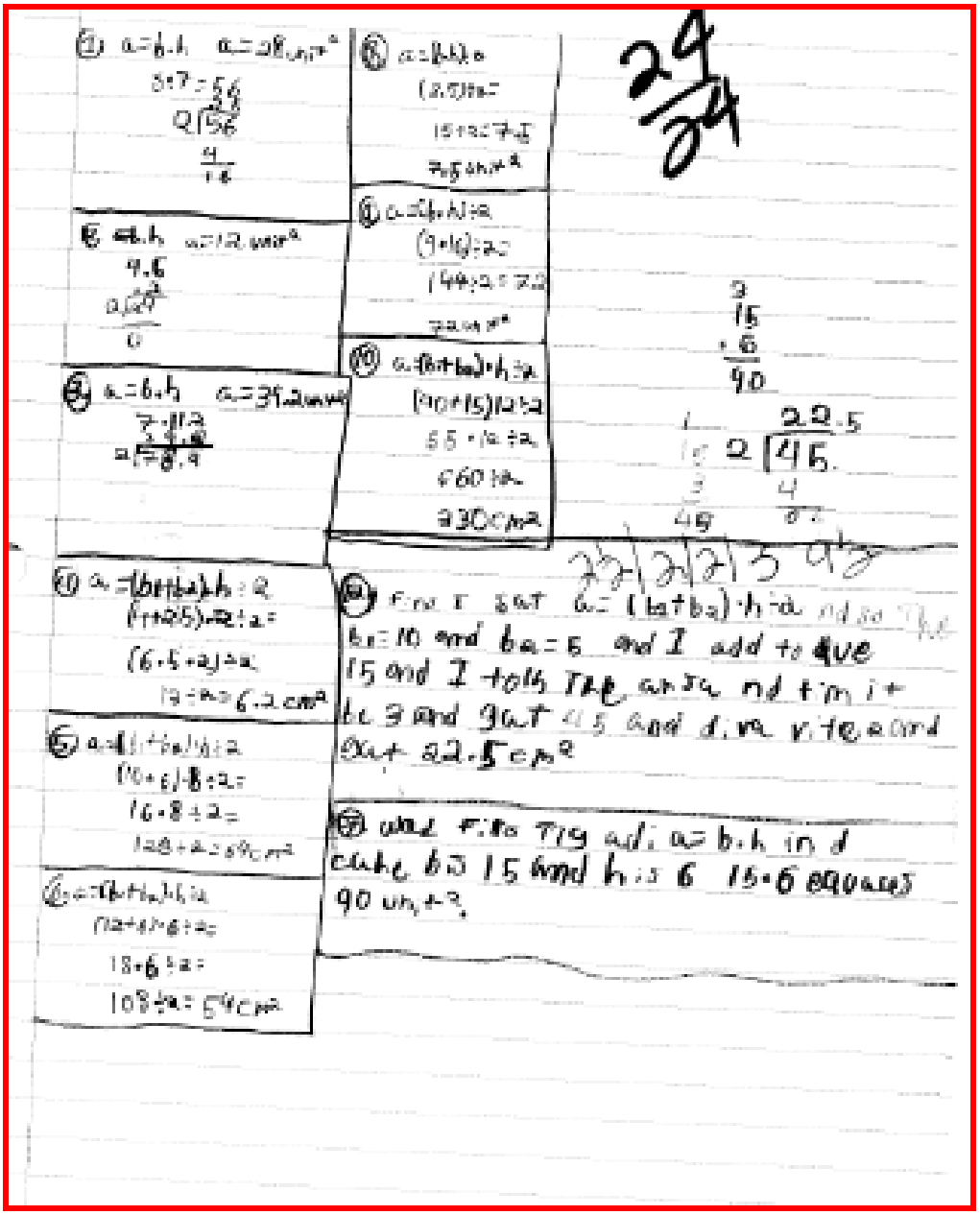
12. $2\frac{1}{3} \quad 7\frac{1}{2} \quad \frac{7}{3} \cdot \frac{15}{2} = \frac{35}{2}$ $2\overline{)35}$ $17\frac{1}{2} ft^2$

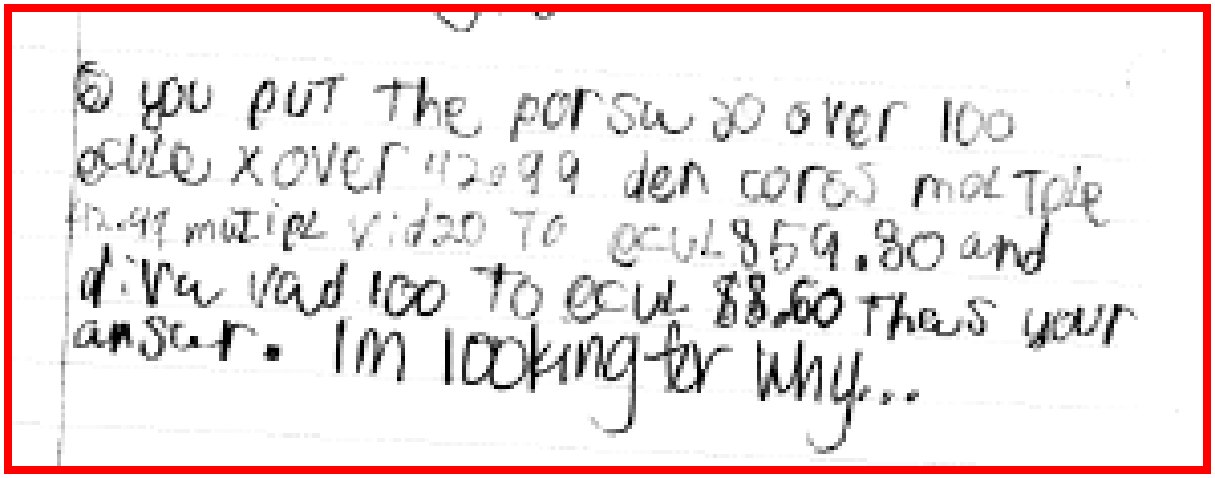
14.

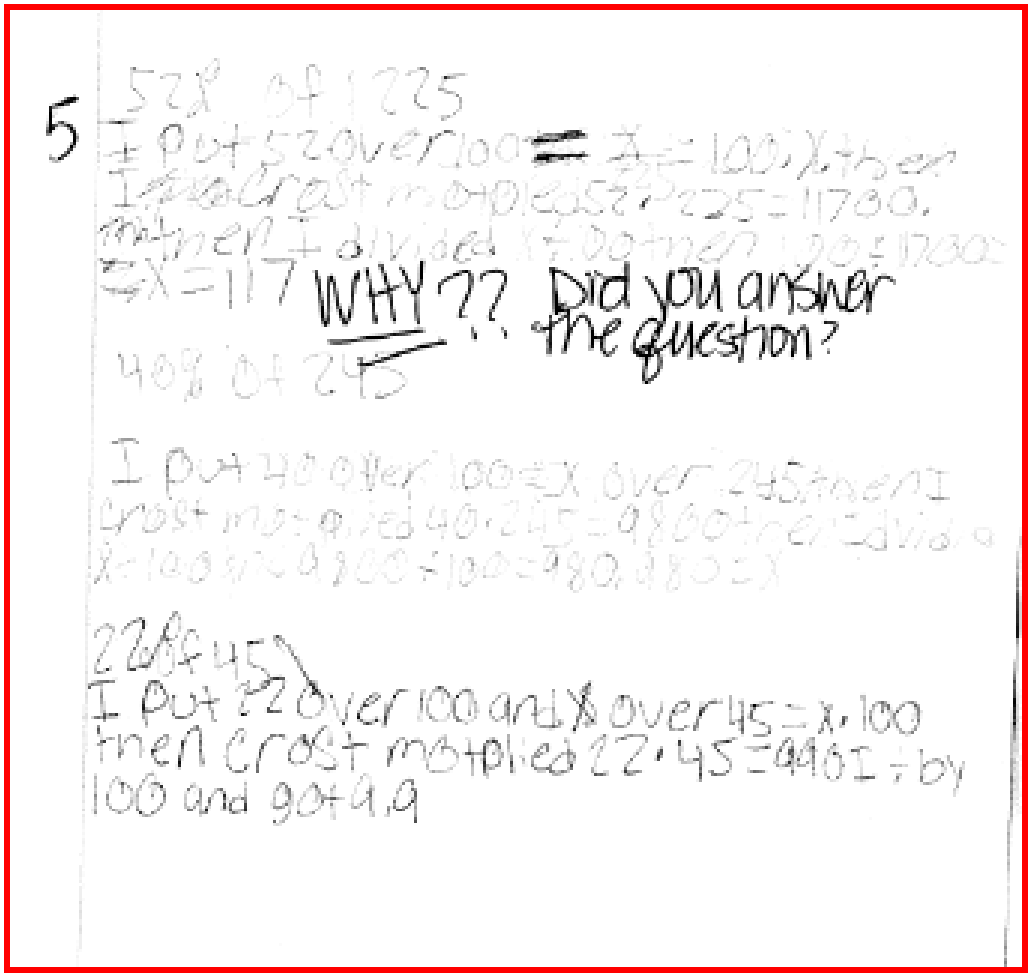
$6 \cdot 4 = 24 \cdot 4 = 96 ft^2$

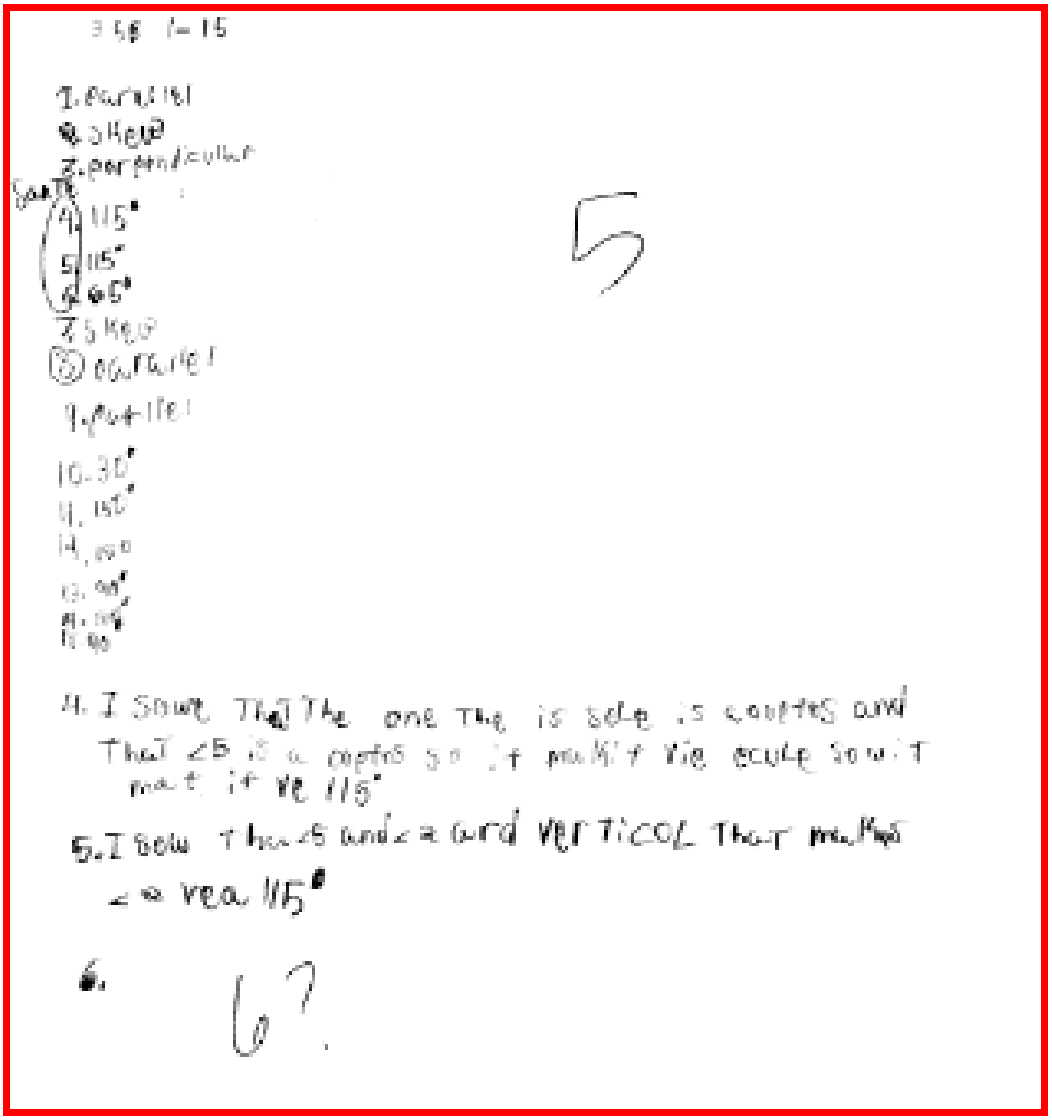
$9 \cdot 12 = 108 ft^2$

I multiplied $6 \cdot 4 = 24 \cdot 4 = 96 ft^2$ that I how much the carpet I chose. Then I multiplied $9 \cdot 12 = 108 ft^2$ that is the the room floor. He can't cover the floor he doesn't have enough carpet.


29/34
22.5
Find out A=(ba+bb)·h÷2
ba=10 and bb=5 and I add to get
15 and I took the area and times it
by 3 and got 45 and divide it by 2 and
got 22.5 cm²
and then I did A=b·h and
cuz b is 15 and h is 6 15·6 equals
90 units²

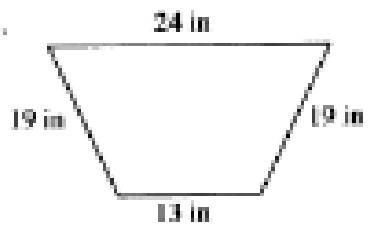

© you put the parsu 20 over 100
ocule x over 112.99 den cores mal Tole
112.99 multiple vidzo To @cul 859.80 and
d:vu vaad 100 To @cu 88.60 Thats your
ansar. Im looking for why..

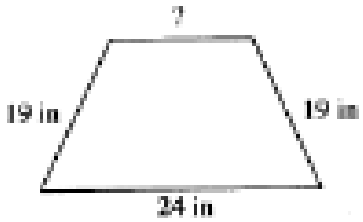

5
WHY?? Did you answer the question?


3 5 6 1 = 15
1. Parallel
2. Same
3. perpendicular
Same
4. 115°
5. 115°
6. 65°
7. Same
8. Congruent
9. Quadrilateral
10. 30°
11. 150°
12. 60°
13. 90°
14. 90°
15. 90°
16. 90°
4. I know that the one that is side is congrues and that ∠5 is a copies so it must be equle so it must it be 115°
5. I know there is and ∠ a card VERTICOL that makes ∠ as vea 115°
6.
5
6?

Find the missing measure in each set of congruent polygons. (1 point each)

28.

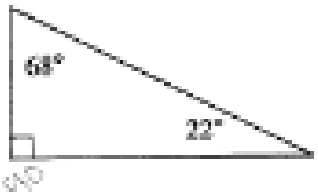


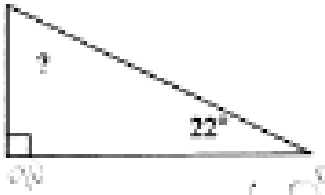


(The corresponding angles of congruent polygons are congruent)

? = 13

29.

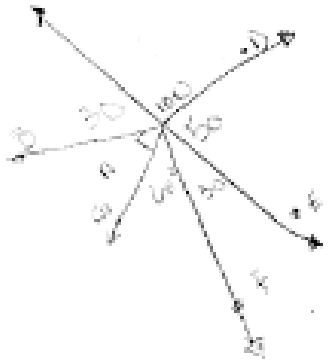


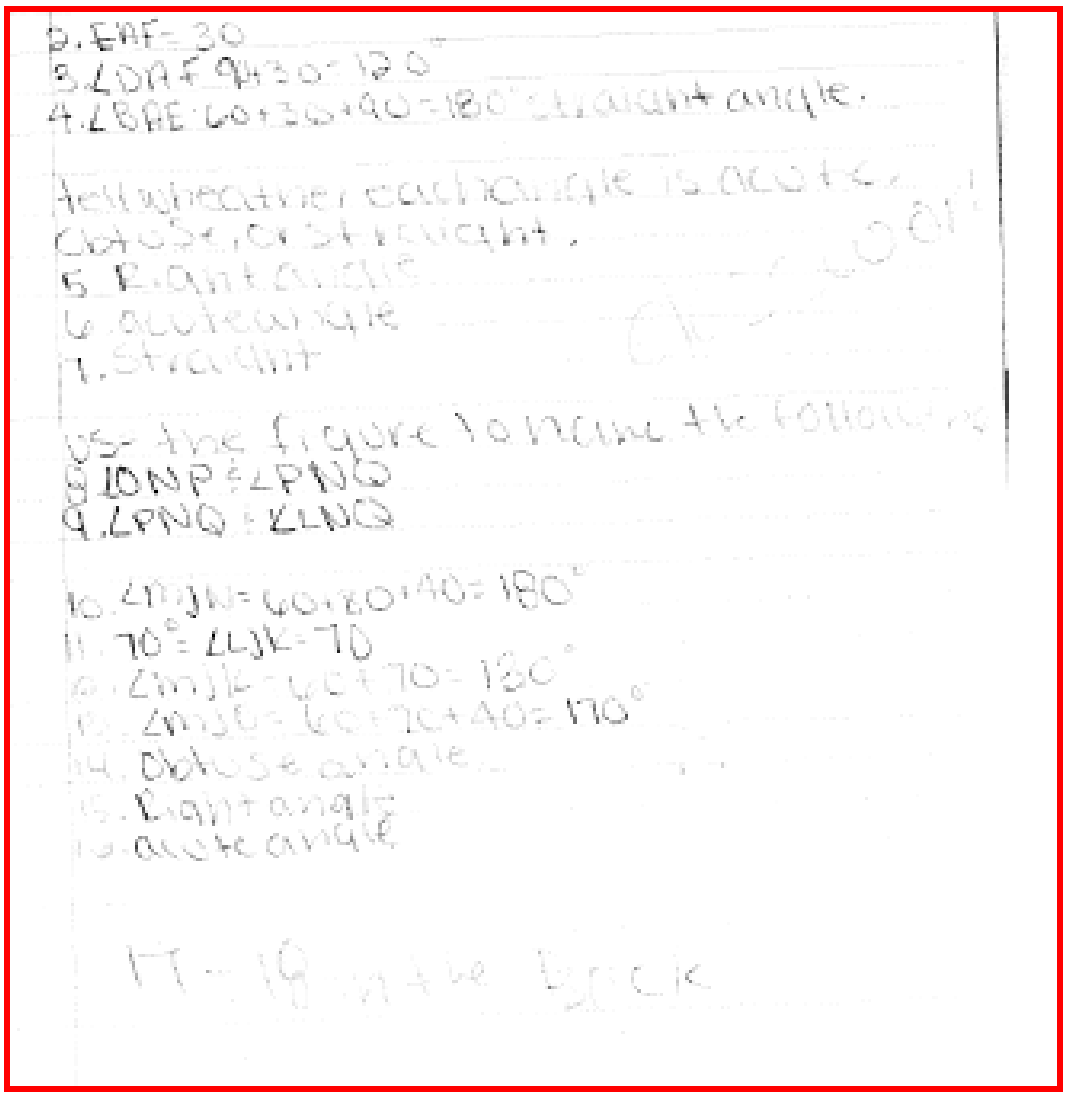


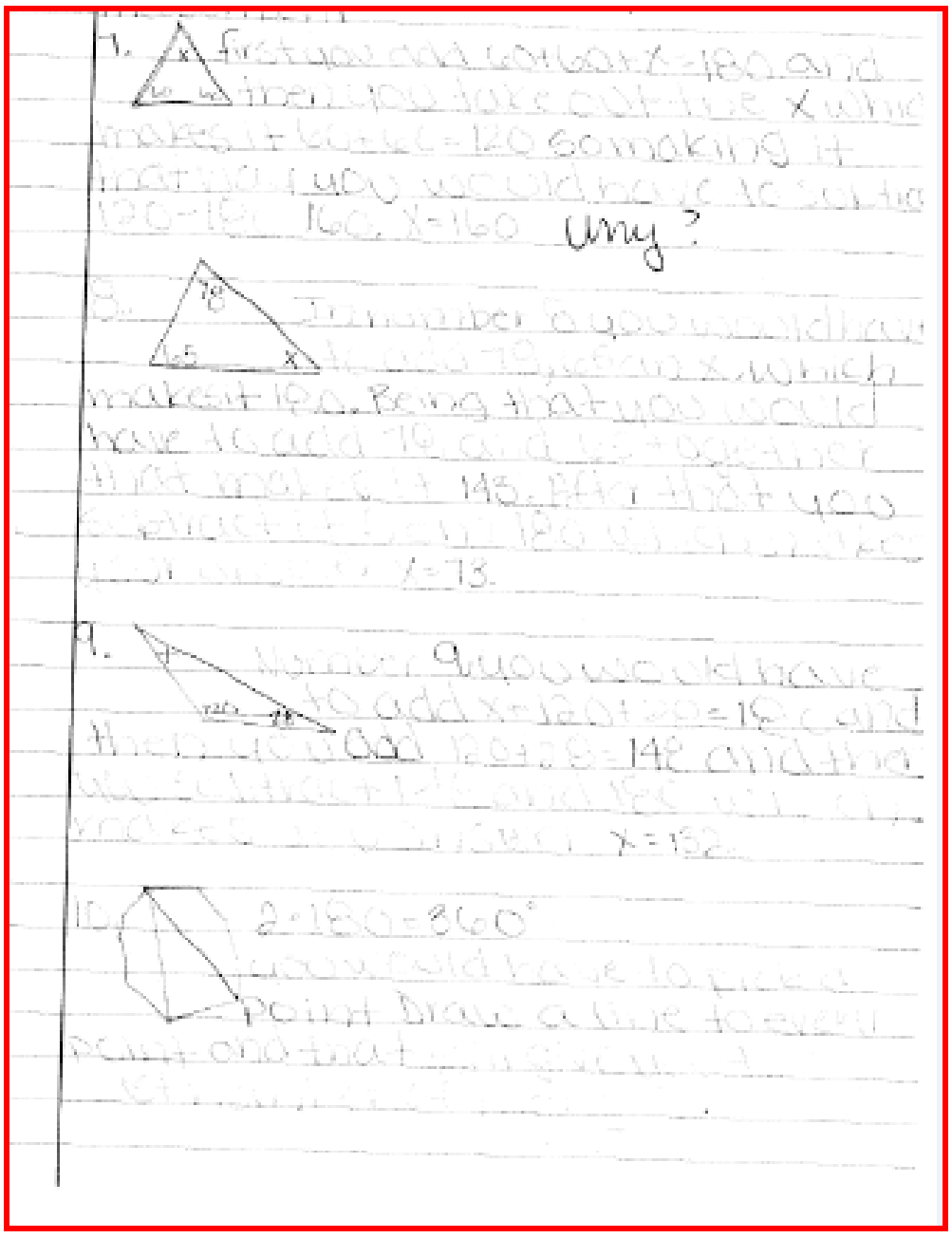
? = 68°

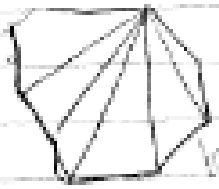
18. C, D, E
first I added point C, point D and then point E.
You could use the number to find your supplementary angle.
You eliminate etc.

17. 4 pairs of complementary angles.
- first, I took the angles C and E to add them together to find my missing angles.
60+30=90° that how you find the complementary angle.
The angle must be 90° exactly.

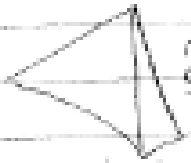





Why?
2·180=360°

11. 

6·180=2480
By picking a point it leads to giving me the least amount of triangles. I got 6 triangles and all triangles are 180

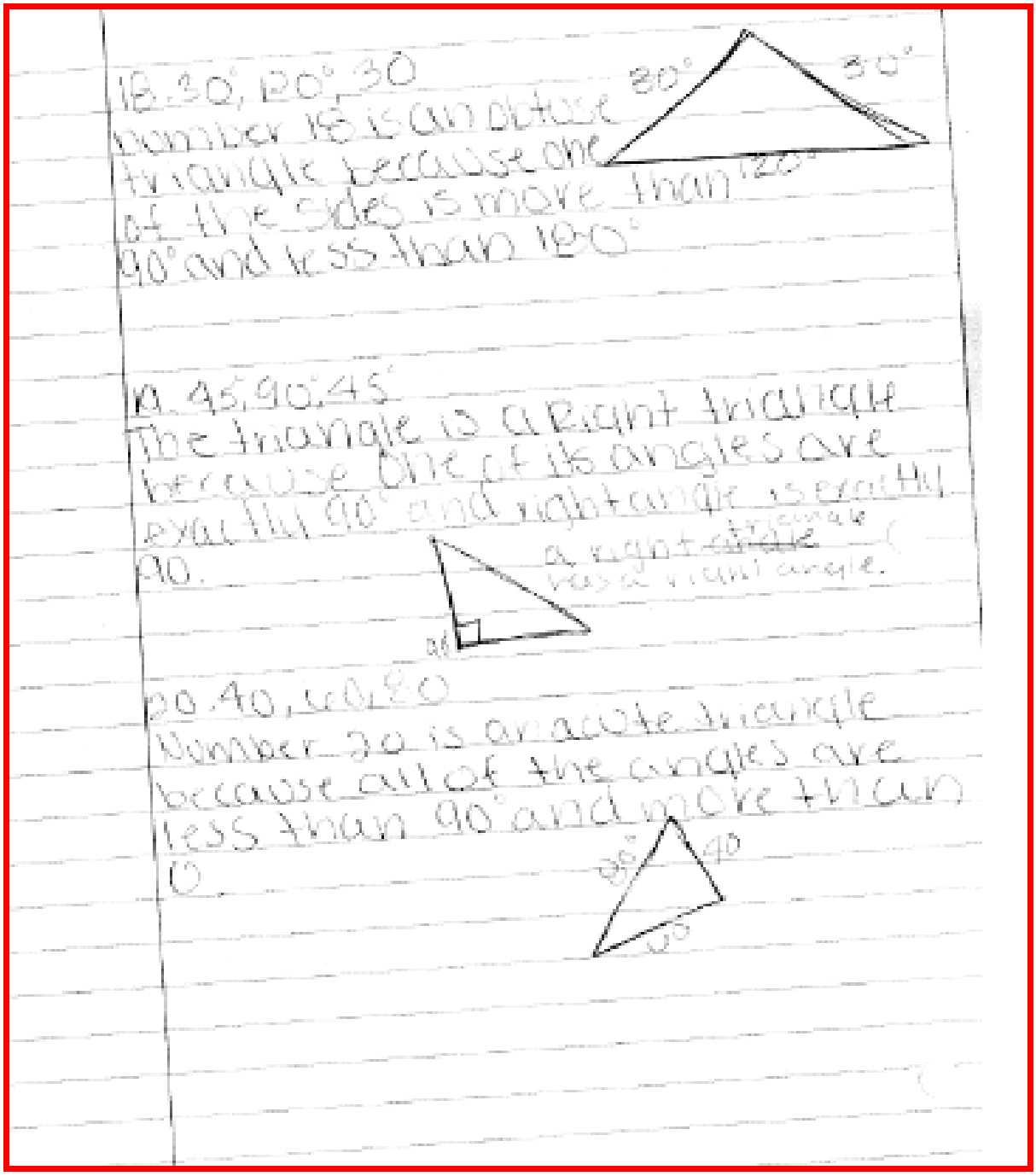
12. 

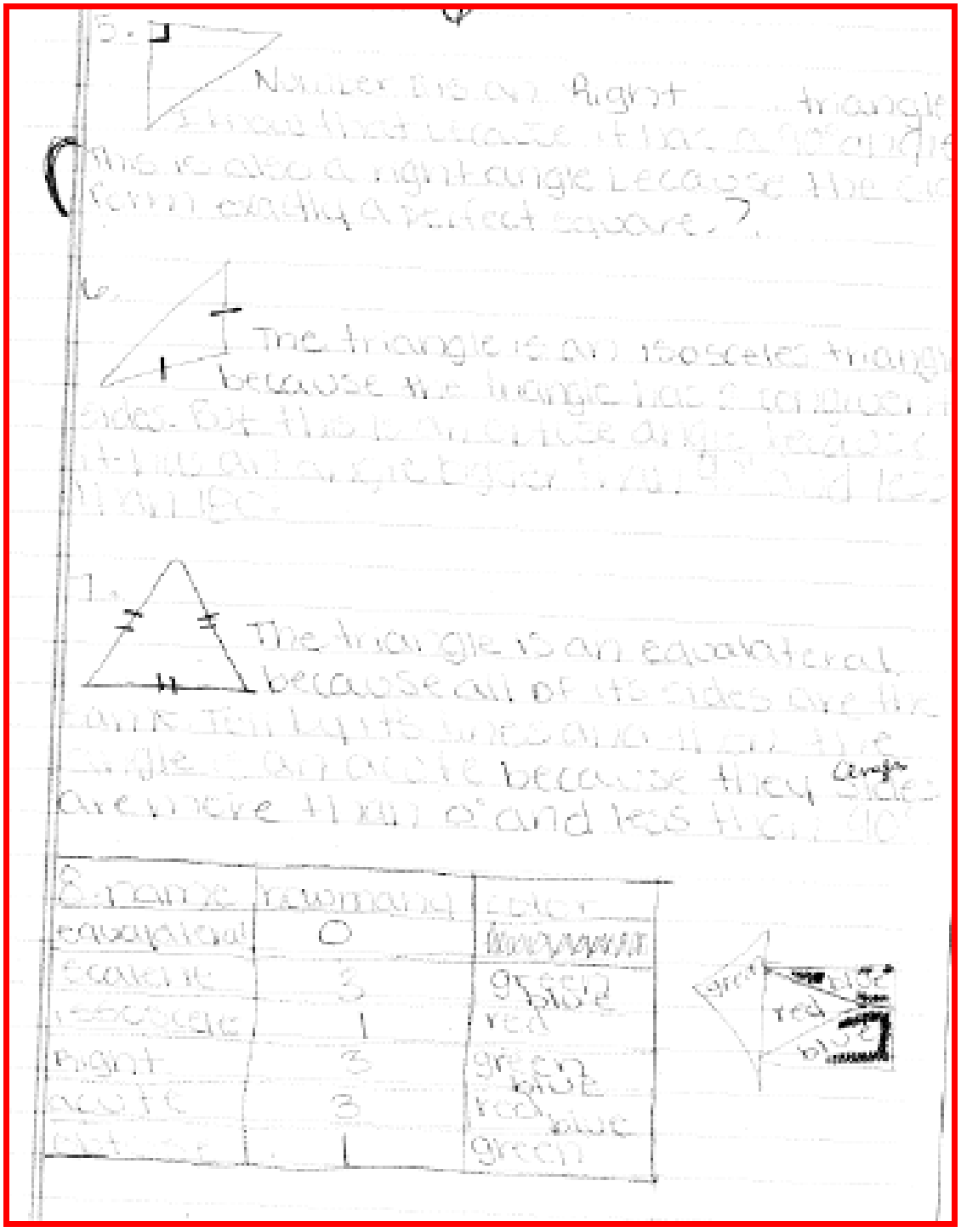
2·180=360
I picked a point got to triangles and then I added 2 triangles and then I added

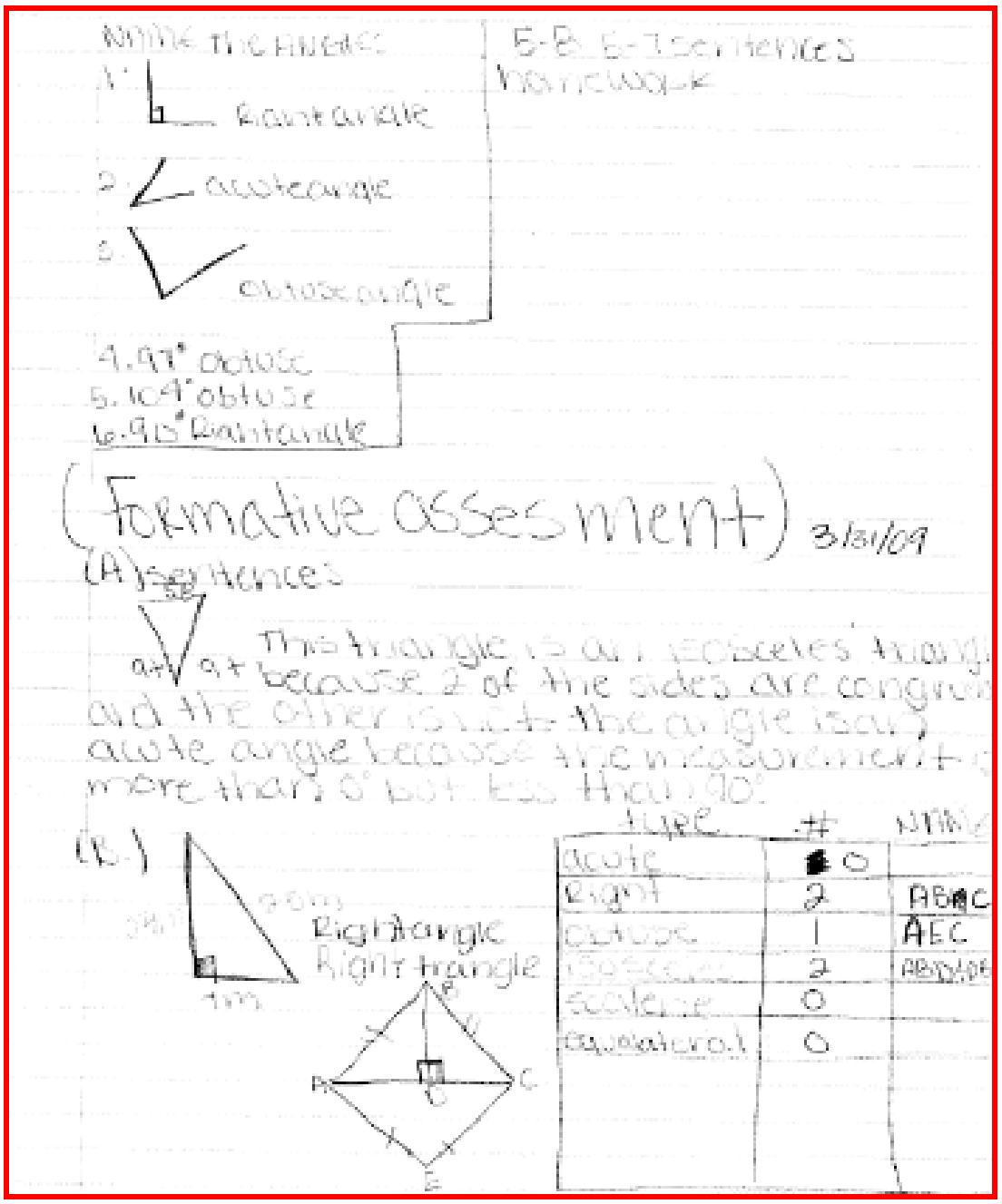
9. 8cm, 5cm, 3cm
number 9 is an acute triangle because all of its angles are les than 90 more than 0°.

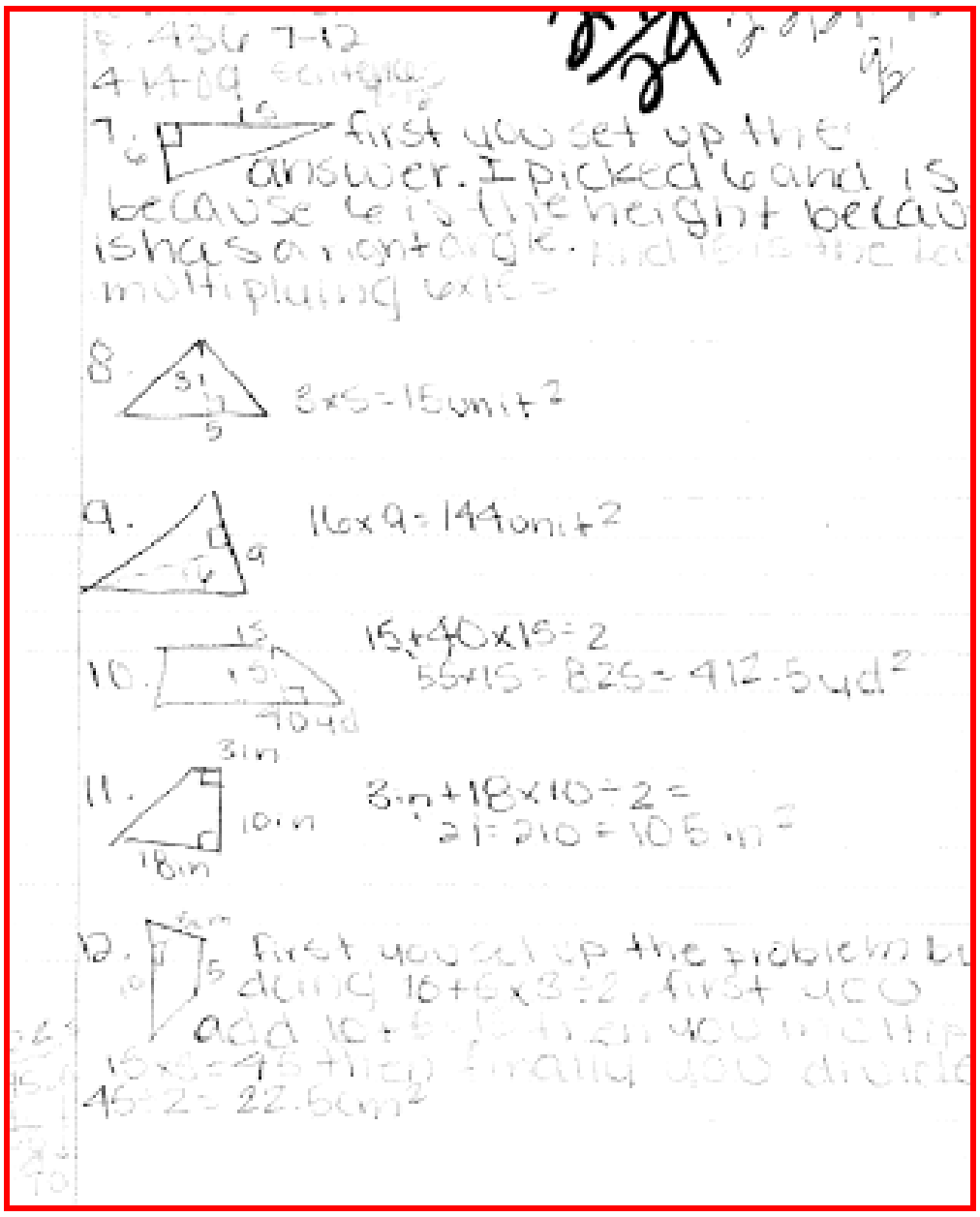
10. 3, 4, 5
number 10 is an acute triangle because all of the angle add up to not being more than 90 or less than 0.

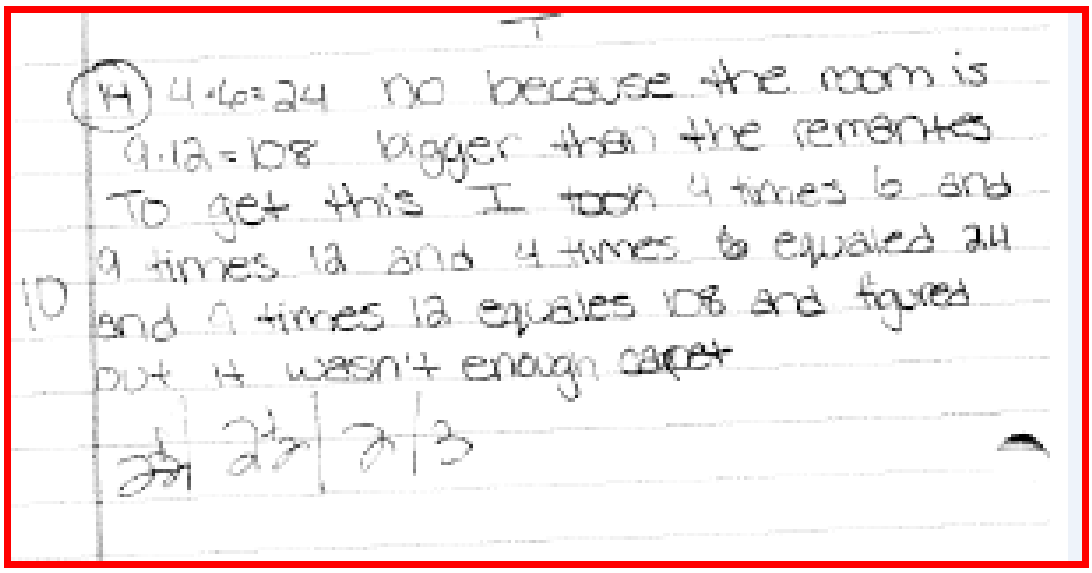
11. 4m, 4m, 4m
number 11 is an equilateral triangle because all of the its sides are equal and the angles are measured.


18. 30, 120, 30
Number 18 is an obtuse triangle because one of the sides is more than 90° and less than 180°
30°
30°
120°
A. 45, 90, 45
The triangle is a right triangle because one of its angles are exactly 90° and right angle is exactly 90.
a right triangle has a right angle.
90°
20. 40, 60, 80
Number 20 is an acute triangle because all of the angles are less than 90° and more than 0.
40
60
80

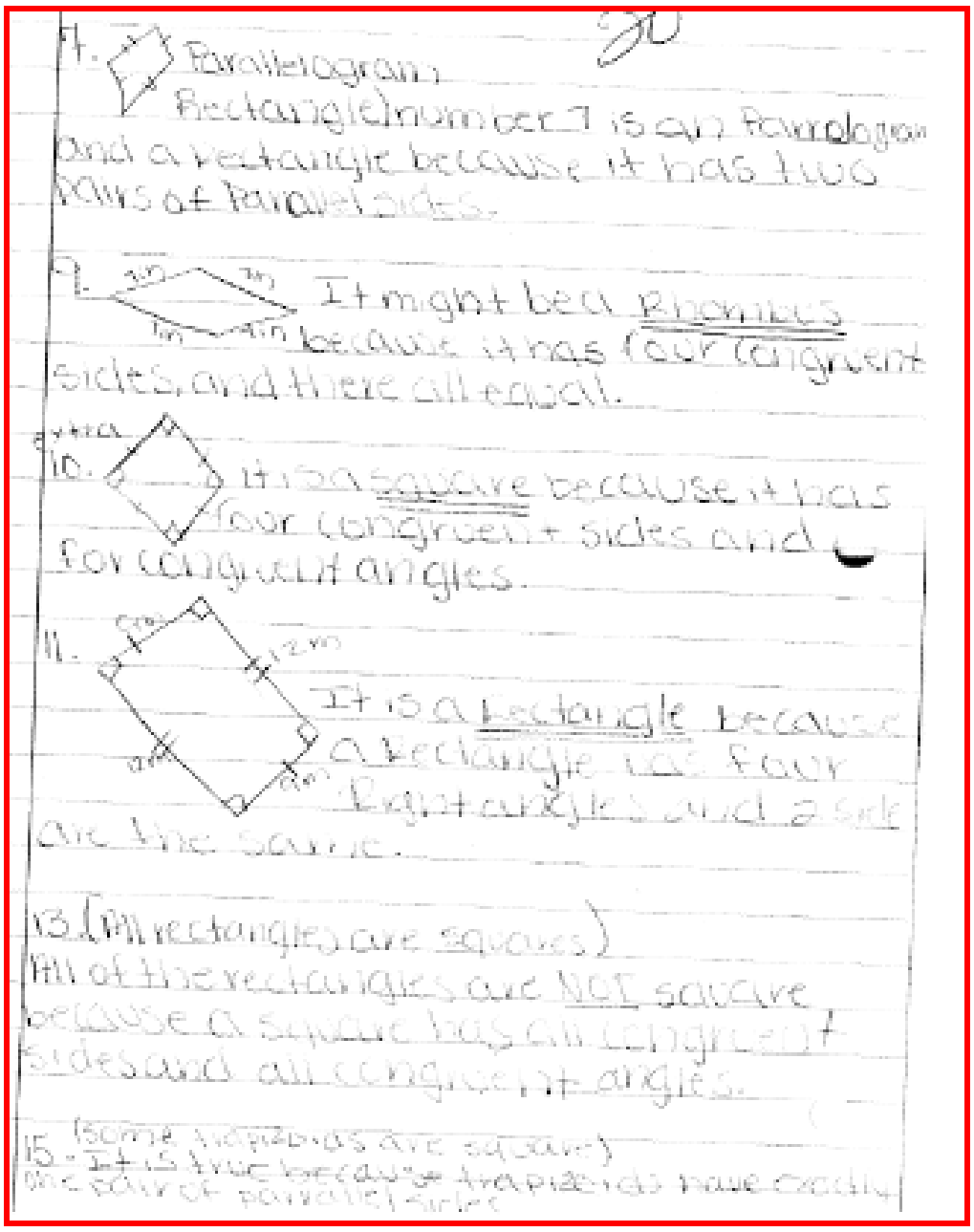

5.
Number 5 is an Right triangle
because it has a
and is also a right angle because the
form exactly a perfect square.
6.
The triangle is an isosceles triangle
because the triangle has 2 congruent
sides. But it is not a right angle because
it has an angle bigger than
7.
The triangle is an equilateral
because all of its sides are the
same length. It is also an acute
because they
are more than 0 and less than
Triangle
equilateral
0
equilateral
3
isosceles
1
right
3
acute
3
green
red
blue


NAME THE ANGLES
1. Right angle
2. acute angle
3. obtuse angle
4. 97° obtuse
5. 164° obtuse
6. 90° Right angle
5-8 E-Z sentences
Homework
(Formative Assessment) 3/31/09
(A) sentences
(B)
Right triangle
Right triangle
A
C
E


7. first you set up the
answer. I picked b and is
because b is the height beca
is has a right angle.
multiplying
8.
3.1
5
8x5=15cm.t²
9.
9
11x9=99cm.t²
10.
15
15
7.04
15x40x15=2
55x15=825=912.5yd²
11.
3cm
10cm
18cm
3.n+18x10÷2=
21=210=105.n²
12.
10
5
first you set up the problem by
doing 10+6x3÷2, first you
add 10+6 then you multip
15x6=90 then finally you divide
45÷2=22.5cm²



(14) 4·6=24 no because the room is
9·12=108 bigger than the remenes
To get this I took 4 times 6 and
9 times 12 and 4 times 6 equaled 24
and 9 times 12 equales 108 and figured
but it wasn't enough paper



7. Parallelogram
Rectangle(number 7) is an parallelogram and a rectangle because it has two pairs of parallel sides.

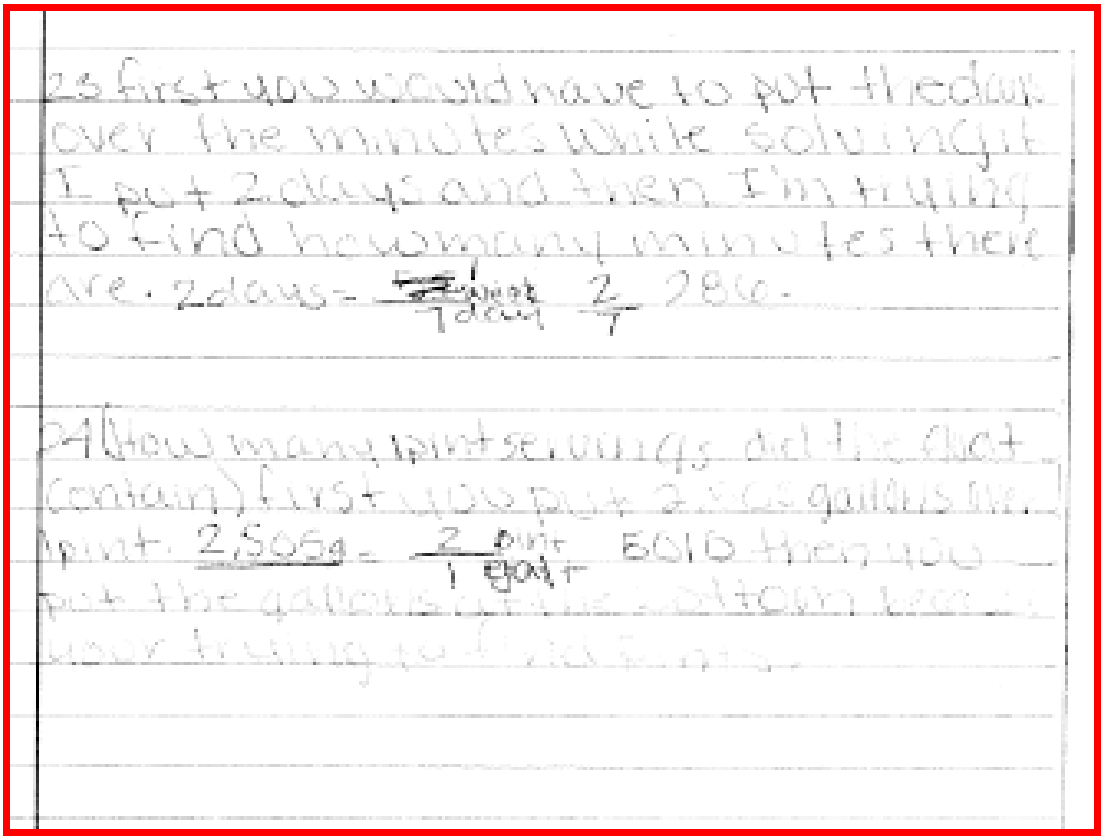
9. It might be a Rhombus because it has four congruent sides, and three all equal.

10. It is a square because it has four congruent sides and four congruent angles.

11. It is a rectangle because a rectangle has four Right angles and 2 sets are the same.

13. (All rectangles are squares)
All of the rectangles are NOT square because a square has all congruent sides and all congruent angles.

15. (Some rectangles are squares)
It is true because a rectangle have each one pair of parallel sides



25 first you would have to put the days over the minutes while solving it I put 2 days and then I'm trying to find how many minutes there are. 2 days = 2 days / 1 day × 24 hr / 1 hr × 60 min / 1 hr = 2880.

24 How many pint servings did the duct contain? first you put 2 1/2 gallons in. 1 pint. 2.5 gal = 2 pint / 1 gal = 5 pint 5010 then you put the gallons in the bottom [illegible]

Appendix J
Student Interview Questions

a. What is your definition of homework?
b. What would your ideal homework be like?
c. How much time one average do you spend on homework assignments?
d. What do you think are the purposes of math homework?
e. Does homework help you? Why or why not?
f. Has the change in homework improved your learning? Why or why not?
g. What frustrates you the most about homework?
h. When you get stuck on a homework problem what do you do?
i. Where can you go to get help with your homework?
j. What do you think are the purpose of homework presentations?
k. Do you like doing homework presentations? Why or why not?
l. Do homework presentations help you? Why or why not?
m. This semester I have changed my teaching practices. What advice would you give me about continuing these changes next year? What were the most and least effective changes in math is semester and why?

Appendix K
(scan and paste copy of interviews)

Appendix L

Student Survey questions

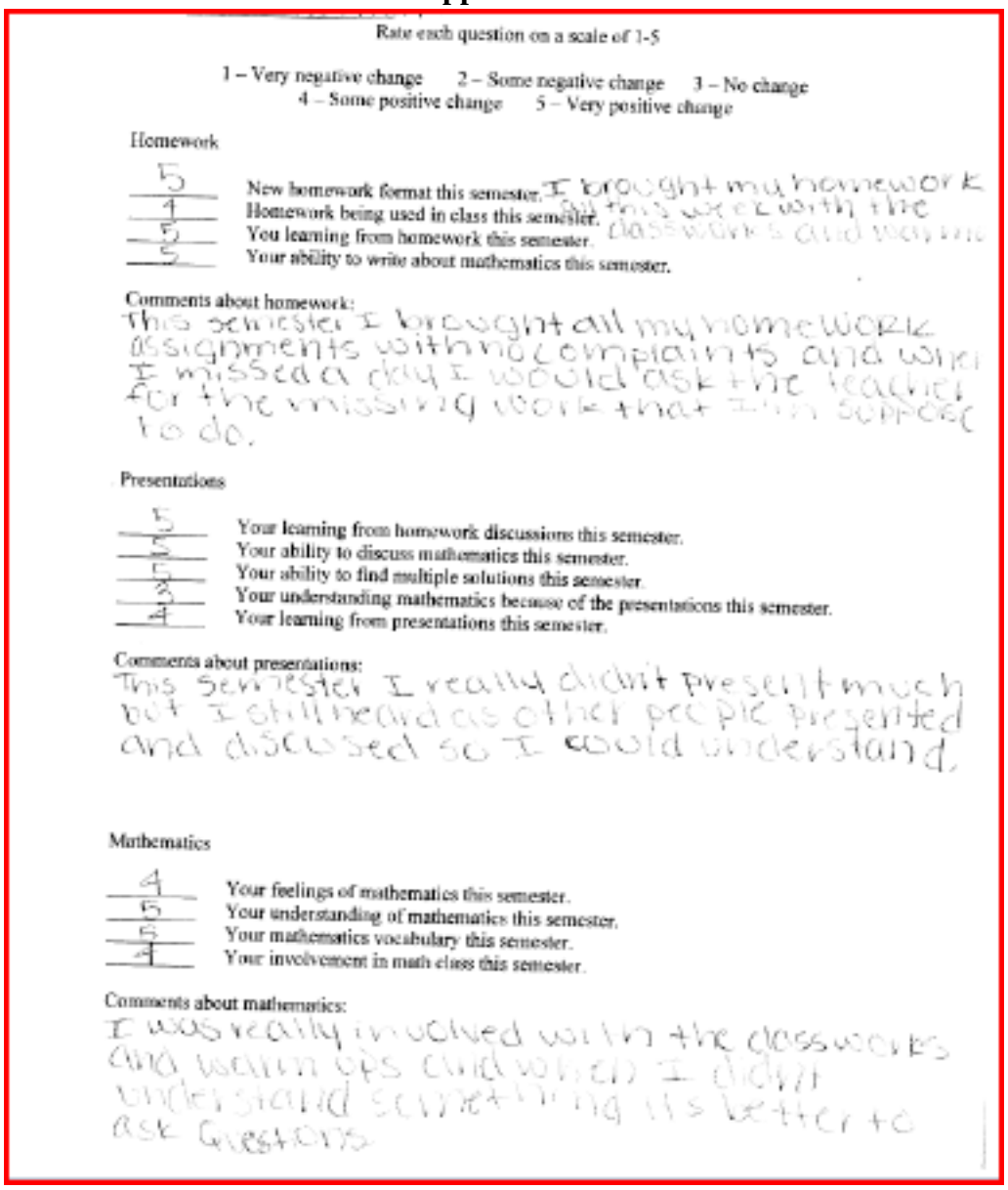
Rate each question on a scale of 1-5
1 Very negative change
2 Some negative change
3 No change
4 Some positive change
5 Very positive change

Homework
_____ New homework format this semester
_____ Homework being used in class this semester
_____ You learning from homework this semester
_____ Your ability to write about mathematics this semester
Comments about homework:

Presentations
_____ Your learning from homework discussions this semester
_____ Your ability to discuss mathematics this semester
_____ Your ability to find multiple solutions this semester
_____ Your understanding mathematics because of the presentations this semester
_____ Your learning from presentations this summer
Comments about presentations:

Mathematics
_____ Your feelings of mathematics this semester
_____ Your understanding of mathematics this semester
_____ Your mathematics vocabulary this semester
_____ Your involvement in math class this semester
Comments about mathematics:

Appendix M



Rate each question on a scale of 1-5

1 – Very negative change 2 – Some negative change 3 – No change
4 – Some positive change 5 – Very positive change

Homework

5 New homework format this semester. I brought my homework
1 Homework being used in class this semester. all this week with the
5 You learning from homework this semester. classwork and when
5 Your ability to write about mathematics this semester.

Comments about homework:
This semester I brought all my homework assignments with no complaints and when I missed a day I would ask the teacher for the missing work that I'm suppose to do.

Presentations

5 Your learning from homework discussions this semester.
3 Your ability to discuss mathematics this semester.
5 Your ability to find multiple solutions this semester.
3 Your understanding mathematics because of the presentations this semester.
4 Your learning from presentations this semester.

Comments about presentations:
This semester I really didn't present much but I still heard as other people presented and discussed so I would understand.

Mathematics

4 Your feelings of mathematics this semester.
5 Your understanding of mathematics this semester.
5 Your mathematics vocabulary this semester.
4 Your involvement in math class this semester.

Comments about mathematics:
I was really involved with the classworks and when ups and downs I didn't understand something it's better to ask questions

Rate each question on a scale of 1-5

1 – Very negative change 2 – Some negative change 3 – No change
4 – Some positive change 5 – Very positive change

Homework

5 New homework format this semester.
5 Homework being used in class this semester.
5 You learning from homework this semester.
5 Your ability to write about mathematics this semester.

Comments about homework: I think homework really helps me no when where check and where am at in class on what to do.

Presentations

5 Your learning from homework discussions this semester.
5 Your ability to discuss mathematics this semester.
5 Your ability to find multiple solutions this semester.
5 Your understanding mathematics because of the presentations this semester.
5 Your learning from presentations this semester.

Comments about presentations:

Mathematics

4 Your feelings of mathematics this semester.
4 Your understanding of mathematics this semester.
5 Your mathematics vocabulary this semester.
5 Your involvement in math class this semester.

Comments about mathematics:

Rate each question on a scale of 1-5

1 – Very negative change 2 – Some negative change 3 – No change
4 – Some positive change 5 – Very positive change

Homework

1	New homework format this semester.
6	Homework being used in class this semester.
1	You learning from homework this semester.
2	Your ability to write about mathematics this semester.

Comments about homework:

Presentations

x	Your learning from homework discussions this semester.
1	Your ability to discuss mathematics this semester.
1	Your ability to find multiple solutions this semester.
1	Your understanding mathematics because of the presentations this semester.
2	Your learning from presentations this semester.

Comments about presentations:

Mathematics

1	Your feelings of mathematics this semester.
1	Your understanding of mathematics this semester.
1	Your mathematics vocabulary this semester.
0	Your involvement in math class this semester.

Comments about mathematics:

Keep OL The god work

Rate each question on a scale of 1-5

1 – Very negative change 2 – Some negative change 3 – No change
4 – Some positive change 5 – Very positive change

Homework

4 New homework format this semester.
4 Homework being used in class this semester.
5 You learning from homework this semester.
5 Your ability to write about mathematics this semester.

Comments about homework: It was okay. It was way new and kinda of more.

Presentations

4 Your learning from homework discussions this semester.
3 Your ability to discuss mathematics this semester.
4 Your ability to find multiple solutions this semester.
3 Your understanding mathematics because of the presentations this semester.
3 Your learning from presentations this semester.

Comments about presentations: N/a

Mathematics

5 Your feelings of mathematics this semester.
5 Your understanding of mathematics this semester.
4 Your mathematics vocabulary this semester.
5 Your involvement in math class this semester.

Comments about mathematics: N/a

Rate each question on a scale of 1-5

1 – Very negative change 2 – Some negative change 3 – No change
4 – Some positive change 5 – Very positive change

Homework

3 New homework format this semester.
4 Homework being used in class this semester.
2 You learning from homework this semester.
2 Your ability to write about mathematics this semester.

Comments about homework:

Presentations

4 Your learning from homework discussions this semester.
2 Your ability to discuss mathematics this semester.
3 Your ability to find multiple solutions this semester.
4 Your understanding mathematics because of the presentations this semester.
3 Your learning from presentations this semester.

Comments about presentations: when people go up to me over head I can learn diffr. ways to do the work

Mathematics

4 Your feelings of mathematics this semester.
3 Your understanding of mathematics this semester.
2 Your mathematics vocabulary this semester.
3 Your involvement in math class this semester.

Comments about mathematics:

Appendix N

Survey results

Homework

Points earned /Total points	Average Points out of 5	
34/45	3.8	New homework format this semester
34/45	3.8	Homework being used in class this semester
35/45	3.9	You learning from homework this semester
35/45	3.9	Your ability to write about mathematics this semester

Points earned /Total points	Average Points out of 5	
35/45	3.9	Your learning from homework discussions this semester
33/45	3.7	Your ability to discuss mathematics this semester
35/45	3.9	Your ability to find multiple solutions this semester
32/45	3.6	Your understanding mathematics because of the presentations this semester
34/45	3.8	Your learning from presentations this summer

Points earned /Total points	Average Points out of 5	
35/45	3.9	Your understanding of mathematics this semester
35/45	3.9	Your mathematics vocabulary this semester
35/45	3.9	Your involvement in math class this semester

Appendix O

Teacher Journal Questions

What changes have I noticed of how I include homework in my instruction?
What changes have I noticed of how I perceive homework?
What changes have I noticed of how students perceive homework?
What changes have I noticed about homework completion?
What changes have I noticed about math discussion?
What changes have I noticed about math language?
Have I noticed students finding more than one method to find a solution?
What changes have I noticed about students' comfort in reading and writing?
What should I think about for next week?